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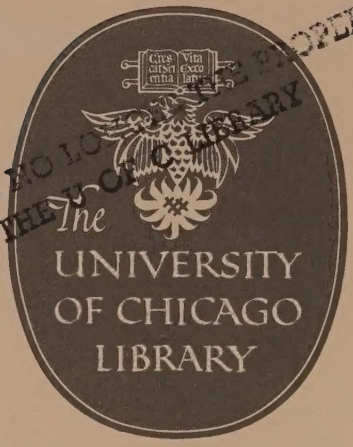

GIFT
of
Esther Golber

BY-PRODUCTS IN THE PACKING INDUSTRY

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BY-PRODUCTS IN THE PACKING INDUSTRY

By RUDOLF A. CLEMEN
Assistant Director, Armour's Livestock Bureau

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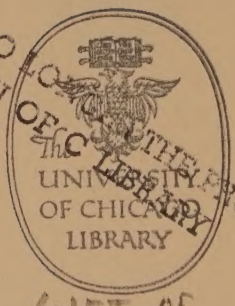

GIFT OF
ESTHER GOLBER

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TO THE MEMORY
OF
J. OGDEN ARMOUR
1863-1927

CAPTAIN OF INDUSTRY
PATRON OF AGRICULTURE
ENERGETIC, CREATIVE, AND DEMOCRATIC
LOYAL, SYMPATHETIC, AND UNOSTENTATIOUS
DURING WHOSE ADMINISTRATION AS HEAD OF
ARMOUR AND COMPANY THE AMAZING DEVELOPMENT OF
BY-PRODUCTS OCCURRED IN THE GREAT INDUSTRY
WHICH WAS EQUALLY HIS WORK AND HIS RECREATION

THIS BOOK IS DEDICATED

PREFACE

The development of by-products in industry is one of the most outstanding phenomena in our economic life. During the earlier periods of American history our natural resources made it unnecessary from a cost standpoint to pay attention to efficient methods of production. However, rising costs of land, labor, and transportation in the last generation, coupled with vastly increased per capita consumption of all products, have forced each industry to add to its operations, thus conserving and even synthesizing many commodities which otherwise would not have been available. From the viewpoint of individual business, this manufacture of by-products has turned waste into such a source of revenue that in many cases the by-products have proved more profitable per pound than the main product.

This movement toward the ever-increasing manufacture of by-products in basic industries arose not only from a desire to enlarge operations with a view to greater profit, but also in order to maintain adequate earnings for dividend-paying purposes. In many cases necessity went still further and required the development of by-products in many businesses in order to avoid being overwhelmed by the competition of other industries, or of other corporations within the same industry. This new competition between separate industries, which has arisen in recent years, has become so keen as to stimulate increasingly strenuous efforts to enlarge the use of customarily waste products. Modern conditions make it almost impossible materially to cut production and distribution expense for the majority of commodities; hence one of the most important opportunities for gaining competitive advantage, or even for enabling an industry or individual business to maintain its position in this new competition, is to reduce its manufacturing expense by creating new credits for products previously unmarketable.

While from the standpoint of individual business this movement toward by-product manufacture has a definite profit motive, from the national point of view it is a part of the conservation movement inaugurated in the early years of the twentieth century. This movement has made remarkable progress in twenty-five years, but it is likely to make even more significant progress in the future. Prophecy is futile, for all former prophecies regarding the ability of American industry to convert the forces of nature to the service of mankind have fallen ridiculously short of the goal ultimately reached.

From another viewpoint, that of business organization, this tendency toward by-product manufacture suggests an increasing vertical integration in American industry. This is an economic phenomenon which is proving most satisfactory for the large-scale production of commodities, especially to supply an international market which can support only a moderate price level.

The American meat-packing industry has furnished one of the most interesting examples of developing by-product operation, and because of its picturesque phases and the diversity of its activities, it has been chosen for this detailed presentation.

While many of my colleagues, specialists in various departments of Armour and Company, have co-operated cordially in the gathering of accurate data in their respective fields, it is impossible to acknowledge much appreciated assistance in each case by name, because of space limitations. However, I desire to mention here specifically the aid and counsel of Lieutenant-Colonel Edward N. Wentworth, director of Armour's Livestock Bureau. The writing of this volume was undertaken as a result of his suggestion that it would be a useful supplement to my former work, "The American Livestock and Meat Industry" (1923). As the preparation of this book has progressed, Colonel Wentworth's co-operation in revising the manuscript, both in content and style, has been invaluable.

Among others who kindly gave me the benefit of their expert special technical knowledge in the preparation of chapters covering their individual fields, to whom acknowledgment is made

here are: E. J. Madden and M. C. Weimar on hides and skins; W. L. Klein and M. Nelson on wool; Myrick Harding, Charles C. Eikel, Dr. J. J. Vollertsen, Dr. J. R. Powell, W. T. McLeod, Frank E. Brandt, E. J. Bell, F. Krause, L. J. Phillips, E. C. Wolff, and James Pearcy on fats, oils, and greases; G. G. Fox on lard and other refinery products; Henry H. Kamsler and A. D. Henss on oleomargarine; Kenneth Warden on soap; Dr. Frederick Fenger and A. C. Henderson on pharmaceuticals; J. E. Milton on casings; M. S. Sheeley on glue and gelatin; C. H. McDowell, F. S. Lodge, and Dr. R. J. H. DeLoach on fertilizer by-products; R. S. Coughenour and Frank D. Warner on certain edible by-products; C. R. Lange, J. F. Derrough, F. L. Stockard, and Walter H. Grell on produce; J. W. Powley on animal feeds; Warren H. Sapp and W. T. Sheehy on management of by-product manufacture through accounts; J. O. McKinsey on organization methods; and O. A. Garson on the illustrations of processes.

Whatever there is of significance in this presentation of the technical and economic phases of by-product manufacture in meat packing is due to the fact that it is not the work of any one man, but the result of a co-operative effort on the part of some of the best-informed men in the packing industry.

RUDOLF A. CLEMEN

ARMOUR'S LIVESTOCK BUREAU
CHICAGO
September, 1927

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CHAPTER I

SIGNIFICANCE OF BY-PRODUCTS

Everywhere in American industries efforts are being made to eliminate wastes. For years the Federated American Engineering Societies have maintained a committee on elimination of waste in industry, analyzing its sources and causes, and making concrete recommendations for its elimination from representative manufacturing enterprises. Similarly, in agriculture an attempt is being made to solve this problem. Certain general principles have been developed for the elimination of waste by extending the manufacture of useful by-products from farm materials and providing a market for them. As a result of these efforts by-products are daily becoming more significant as a source of revenue.

Probably the most difficult factors in waste utilization are emphasized in agriculture. Several requirements on which agricultural by-product developments are based, which stand out as applicable in all industries, are: First, there is the necessity of a practical commercial process of manufacture. Second, there must be actual or potential market outlets for the new proposed by-products. Third, there is the need of adequate supplies of the waste used as raw material, gathered in one place or capable of being collected at a sufficiently low cost. For example, in the meat industry it was impossible to make use of offal during the period of the local butcher and slaughter-house. It was only when these wastes became accumulated in large quantity, due to the growth of large-scale packing plants, that they could be used as raw material for by-product manufacture. Fourth, there is the requirement of cheap and satisfactory storage from crop to crop in the case of agriculture, or for perishable materials, such as in the meat-packing business. Finally, there is the need of technically trained operatives. These requirements have been met only gradually in many industries.

At the present time profitable by-products are derived from numerous farm crops and industrial operations. For example, straw is a by-product of wheat; stover is a by-product in the growing of corn; calves are a by-product in the dairy industry; and in the eastern part of the United States, particularly, manure is a significant by-product in the fattening of cattle. Gas is an important by-product of the coke industry, and numerous by-products occur in oil refining. Indeed, the materials from which the by-products in nearly all industries are manufactured today were formerly partially or wholly wasted, and the change to intensive utilization of these materials for by-product manufacture has been brought about by the ever-increasing force of competition in American business, both between individual concerns within a single industry and among different ones. The result is a more thorough, competent, and scientific management of all American national industries.

The Rise of Packing-House By-Products

In the packing industry, production and distribution of by-products has long been one of its distinguishing characteristics. About fifty years ago the modern era in the packing industry began with the establishment of large-scale packing-houses able to handle all the livestock offered and to distribute the meat and by-products on a national and international scale. Mechanical refrigeration and the refrigerator car aided this expansion and the efficiency, sanitation, and economy of large-scale packers became widely known. With the rapid growth of the industry, by-products were developed, but the early efforts did not necessarily discover the highest or most valuable use, or the most economical methods of manufacture. There grew up around the larger packing plants a number of separate satellite industries, which bought the unfinished by-products of the plants. For example, large refineries took the non-uniform steam-rendered lard of packers, refined and bleached it, and sold it on the open market. Butterine manufacturers used neutral lard and oleo oil from packing plants for manufacturing oleomargarine. Soap factories bought various grades of tallow. Fertilizer plants carted off the pressed tankage

and raw or pressed blood, dried and sold it as such, or manufactured mixed fertilizer. Glue works made glue from bones, sinews, and various other materials from packing plants. With time, however, the production of these by-products was taken over by the packer himself, until a packing plant was a self-contained institution, performing a series of integrated services. The smaller industries dependent upon packers for raw materials disappeared after they had shown the profitable use of by-products and the vital necessity of scientists, bacteriologists, and chemists, with their laboratories.

The first packing-plant bacteriologists and chemists found a great, flourishing industry. But curing processes were still managed by rule-of-thumb methods, although an effort had been made to standardize and understand them. Hides were handled by the time-honored method of dry-salting; sheep skins, by empirical methods developed in the tanneries. Kettle-rendering and steam-rendering processes were in use for the recovery of lard and tallow, while bleaching and refining methods were just developing and were not in universal use. Tankage and blood were handled by pressing and drying; bones were utilized only in part for gelatin and glue. Much of the bone output was still sold as raw bone meal, a most unfortunate waste of raw material for gelatin and glue, which has not yet been entirely corrected. The commercial fertilizer industry had hardly begun, for the packing-house and even the animal fertilizer branch was but partly developed. It was clearly seen that a great future in by-products was to be expected, but how this future was to be realized, what by-products were the most important, and how they were to be worked to best advantage were unanswered questions.

Development differed from one company to another. Some went so far as to enter branches which were not very logical side lines of the packing industry. Others went very slowly into the development of by-products. Soap making was not looked upon as a necessary part of the packing business. The vegetable oil industry had not been added to the business in animal fats. Margarine was being made, but only in small quantities.

The industry was growing so rapidly in the nineties that the

main effort was placed on the primary products, and the by-products were developed rather haphazardly by accretion and accidental skill within an individual company. Many methods were sound and practical, but many were unsound and unscientific and could have been corrected by science at the outset. This made

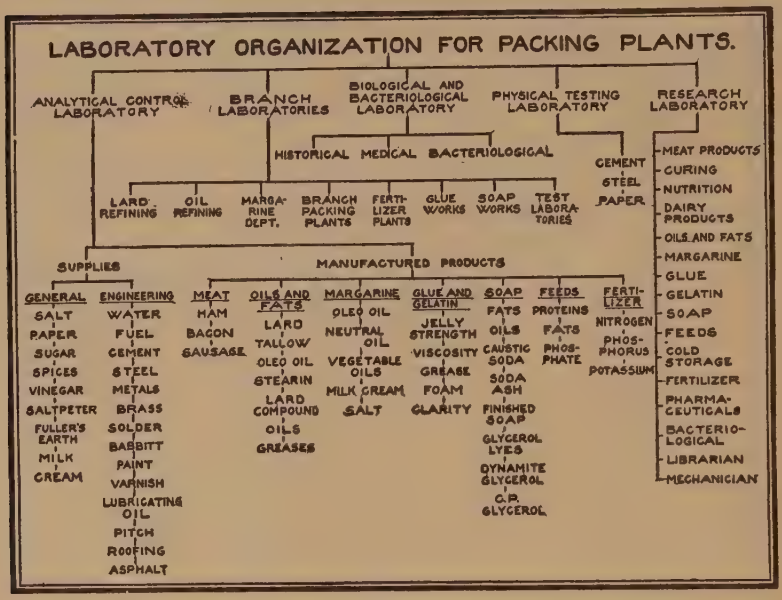


FIG. 1

necessary the later application of corrective methods, and it is this work which is largely directed by the methods of chemical control.

CHEMICAL CONTROL

The packing industry is, at the present time, interwoven with the development of physical and chemical science. Indeed, its expansion depends to a large extent upon scientific research. While the early packing-house chemical laboratory was a control laboratory, and the chemist took samples of fertilizer or tallow and performed the necessary routine work, there soon developed a number of departments corresponding to the principal departments of the plant which required analytical work (see Fig. 1).

By this plan of organization each department of the plant came to have a section in the laboratory where its work is given first attention by men thoroughly familiar with the methods used and the products to be analyzed, e.g., fats and oils, fertilizer, and inedible greases.

The by-products of a modern packing plant are continually being developed into others of greater value. Recent instances of this extension of by-products are the recovery of oil from soap stock, the manufacture of blood albumen from liquid blood, and the recovery of used pickle. Of immediate interest for public health and welfare is the problem of the disposal of packers' sewage in congested municipalities. Much research has been done on this problem by both chemists and bacteriologists in co-operation with each other. The result has been the development of processes by which bacteria are enabled to work on the solid matter in the sewage, which is dissipated by conversion into soluble material and gases. Already a practical commercial system has been designed which has been installed successfully in several municipal centers of importance in the United States and in many progressive packing plants.

The development of chemical control has made practical the distribution of packing-house products not only nationally, but internationally. Thus, chemists started with refrigeration, with control of the curing process, and with control of canning. Their first problems were fundamental ones in bacteriology, viz., those of preventing deterioration in a perishable product, meat. Their work, and all subsequent research with its results, grew out of the original discoveries of that pioneer, the father of bacteriology, Louis Pasteur. Building hereupon, the application of chemical science to the by-product problems of meat-packing has made possible its growth into one of our largest industries, through the efforts of such representative chemists as Dr. A. G. Manns, Dr. J. P. Grabfield, Mr. H. B. Schmidt, Mr. W. B. Allbright, Dr. W. D. Richardson, Dr. Arthur Lowenstein, Dr. J. J. Vollertsen, and others.

Within the packing industry the manufacture of by-products

has had great influence upon production methods, the distribution system, and the financial operations of individual packing companies. Generally speaking, this influence can be summed up in one word—integration—which simply means an extension of the manufacture of by-products from the raw material of the industry to the most highly finished and delicate results of the latest discoveries of scientific investigation. This is usually known as vertical integration, and can be seen in each of the main by-product divisions, such as hides and skins, wool and hair, fats, oils, and greases, pharmaceuticals, glue and gelatin, animal and poultry feeds, in each of which there has been a continuous process of additions to by-products. For research is continually extending the boundaries of by-product knowledge.

Representative By-Products

Summarized, this great variety of packing-house by-products falls into two divisions: edible and inedible. The edible products, such as are prepared from hearts, livers, brains, ox tails, kidneys, sweetbreads, tongues, fats, rennet, and blood show this process of integration, but it is among the inedible products that we find the greatest development of this kind. The inedible products are subdivided into a number of representative classes, as follows:

Products from wool, hair, and hides.—All kinds of leather, brushes, binder in plaster, felt, padding, hair for upholstering furniture and for mattresses, glue, and lanolin.

Products from sinews, fats, and blood.—Blood meal, albumen, filler for leather, fertilizer, meat meal, illuminating and lubricating oils, glue, case-hardening bone, gelatin, isinglass, benzoinated lard, lard stearine, mutton, and tallow.

Products from glands and viscera.—Sausage casings, gold-beaters' skins, perfume-bottle caps, tennis strings, clock cords, drum snares, violin strings, surgical ligatures, pharmaceuticals.

Products from bones.—Combs, buttons, hairpins, umbrella handles, napkin rings, tobacco boxes, buckles, crochet needles, knife handles, dice, chessmen, electrical bushings, washers, artificial teeth, bone rings for nursing bottles, glue, case-hardening bone, gelatin, fertilizers, oils, soap grease.

Pharmaceuticals.—Pepsin, pancreatin, thyroid extract, adrenalin, ben-

BY-PRODUCTS FROM CATTLE

zoinated lard, pituitary liquid, pineal substance, thrombo-plastin, red bone marrow.

Other by-products.—Not included in the foregoing classifications are: lard, soap, candles, glycerin, tallow, neatsfoot oil, rennet, and oleomargarine.

However, this process of integration in the packing industry and its by-products differs from what is normally understood as integration by the professional economists. While many of the products already referred to are manufactured by certain of the national packers themselves, or through subsidiary corporations such as leather and tanning companies and fertilizer companies, in many instances by-products processed to a certain degree within the packing industry proper are transferred to other subsidiary industries over which individual packers have no control, for further elaborate and expensive processing into final, highly finished articles. Outstanding examples of enterprises for which the packing industry furnishes the raw material are glue and gelatin and the animal-feed manufacturing business.

Definition of By-Products

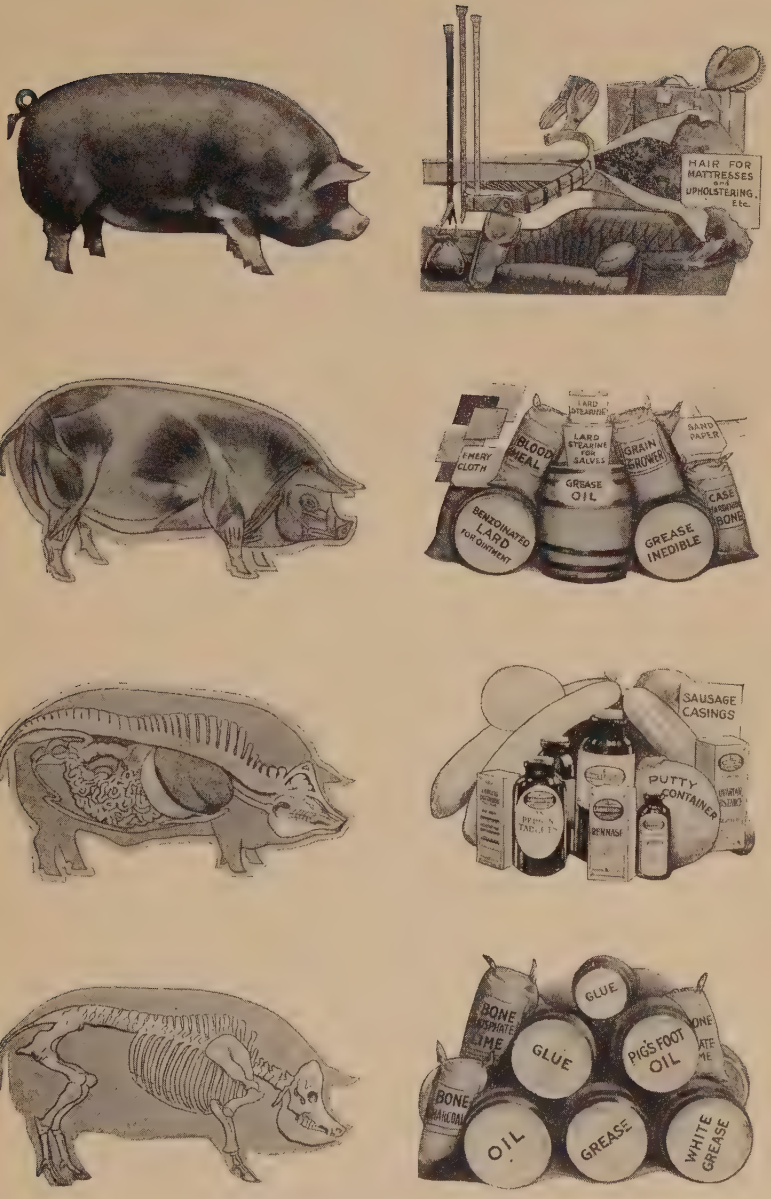
The relation of by-products to the packing industry can be understood more clearly when the term itself is more clearly defined. In its trade use, the term "by-product" is employed to include almost anything, from the goat skin and wool known in the early biblical days, to the ultra-modern nugget-like little pineal gland from the brain lobe of a steer. Indeed, by-product is one of the favorite words used regarding the packing industry. Yet its exact definition is elusive. There is no difficulty in pointing out soap, fertilizer, and violin strings as conspicuous examples of what a by-product is, and fresh and salt pork, beef, and mutton as examples of what a by-product is not. For the latter are main products of the packing industry. Other products, however, cannot be classified so easily, for example, sausage—either fresh, smoked, or dry—oleomargarine and poultry, eggs, butter, and cheese. A classification of products and by-products is made by the packer for his practical purposes of plant organization and cost figuring. He lays down and follows definite rules, both for

the definition of by-products and the stage of the manufacturing process at which an appraisal is made of their value. As a general rule, a packer considers as a by-product everything of value produced on the killing floor other than dressed meat. In his cost accounting the packer gives credit for the then present value of these by-products, of which action the logic is obvious. Applying this rule to the products already mentioned, it is clear that the term "by-products" includes them all. In thus defining by-products it is necessary to distinguish between by-products of processing and manufacturing on the one hand, and by-products of selling methods and distribution equipment on the other. For example, produce commodities, such as poultry, butter, eggs, and cheese, really fall under the head of by-products of selling methods and distribution equipment.

The meat packer is primarily engaged in the preparation of meats. Some packers stop at this point and sell most of their by-products in a raw state as they come from the killing floor. Many packers process by-products beyond this initial stage, while others manufacture goods which are not strictly packing-house products, such as soap, oleomargarine, compound lard, stock feed, glue, etc. These businesses, irrespective of whether or not they are conducted by a packing company, buy their materials partly from packers and partly from outside concerns. In the manufacture of compound lard, for example, the purchase of vegetable oils is necessary. Obviously, in the manufacture of soap, many materials are necessary that are not produced as by-products of the meat-packing industry. It is evident that any profits or losses that a packer sustains in these lines cannot properly be considered as profits or losses of the meat business, for the reason that these are distinct competitive industries.

Returns from By-Products

Many statements have been made regarding the value of packing-house by-products which are somewhat inaccurate. While it is true that the returns from the manufacture of by-products are very large in the aggregate, due to the immense



BY-PRODUCTS FROM HOGS

volume, the total return is a minor one compared to that derived from the sale of the main product of the packing industry, namely, meat. The proportion of income from by-products differs with each class of livestock. This amount for each kind of livestock is shown in the form of percentages in Table I.

It is clear from this statement that the greatest percentage returns come from by-products of the steer, although they are followed rather closely by the returns from sheep by-products. The percentage of return for the hide or pelt, the principal by-product, is almost twice as much in the case of sheep as in the case of cattle.

TABLE I

	Percentage from Meat	Percentage from By-Products	Percentage from Hide or Pelt
Hog	96.6	3.4	Sold with carcass
Sheep	81.4	4.1	14.5
Calf	92.8	7.2	Sold with carcass
Steer	87.3	4.1	8.6

For hogs the money return from by-products is only about 3.5 per cent, compared with the percentage return from pork of 96.6 per cent, the main product of the hog. However, due to the immense number of hogs slaughtered under federal inspection each year in the United States—between forty and fifty million—the total return on the by-products of hogs is very considerable. The situation regarding hog by-products can be expressed interestingly by a volumetric division of the by-products into the two main classes indicated, namely, edible and inedible, resulting from the slaughter of a 250-pound hog. Including plucks, gullet meat, weasand meat, giblet meat, tongues, and kidneys, the edible by-products amount to about 3.5 per cent, or for a 220–250 lb. hog about 7–9 pounds, while the inedible by-products amount to 3.75 per cent, or 9.38 pounds. One can readily see that even with this small amount per hog, the total volume of by-products for the hogs killed under federal inspection in the United States is of great economic value in the country's commerce.

Similarly, and in a little more detail, on account of the greater

importance, the relation of the amounts of the various main by-product classes, resulting from the slaughter of an average steer, is given in Table II.

This table indicates the physical basis of the further by-product operations which will be described at some length in the following chapters. The relatively small percentages of any one class of raw materials, and the fact that the materials of no value which must be discarded as waste amount to 10 per cent of the

TABLE II

WEIGHTS OF VARIOUS STEER PRODUCTS

	Percentage of Green Product	Percentage of Finished Product to Live Steer
Beef	55.6	54.3
By-products:		
Hides	7.2	5.9
Fats	5.0	3.3
Head	3.4	2.2
Feet	1.5	1.1
Blood	3.8	.7
Casings	1.2	.8
Miscellaneous	5.4	.....
Valueless materials	10.1	10.1
Shrinkage	6.8	6.8
Additional shrinkage through processing	.....	11.6
Total steer	100.0	100.0

total steer weight, made absolutely necessary the development of an efficient operating technique in order to derive from it commercially useful and financially profitable articles of commerce.

For the individual steer, returns from by-products are much larger than for a hog or sheep. This fact is due largely to the relatively high value of the hide. The hog does not yield any by-product comparable to this. Taking as a base an average steer from which are derived the various classes of by-products, a consideration of the proportionate financial return from beef and raw by-products would show that the by-product returns are only a little less than one-sixth of the amount received from meat. Yet the returns from the by-products of cattle under normal conditions

BY-PRODUCTS FROM SHEEP

more than enable the packers to offset their operating and selling expenses.

In the following chapters there are considered in some detail the by-products of the packing industry. In order to present a clear picture of by-product manufacture, these have been treated in a small number of logical groups, such as hides and skins, wool and hair, and fats, oils, and greases. Each group is taken up both from the technical and the economic standpoint, to give unity to the discussion. The importance of each by-product group of commodities is estimated, a survey of the individual products is made, some description of their technical processing is given, and also a discussion of such economic problems as the tariff, prices, production, distribution, trade, and consumption. Following logically from this survey is a chapter on the management of by-product manufacture as a part of the packing industry. This is a summary of by-products from the standpoint of the business executive, considering their production as a source of revenue, through application of accurate accounting and organization methods. The final chapter contains a look into the future of by-products and an estimate of some possibilities in waste elimination and the general types of new by-products which may yet be developed in the American meat-packing industry.

CHAPTER II

HIDES AND SKINS

Hides and skins have been articles of commerce from the dawn of history. Long before meat entered international trade, hides and skins were carried across Turkestan and other parts of Asia by caravans. The Babylonians knew how to tan hides. The Egyptians employed leather for most of the purposes for which we use it today, and they taught their methods to the Hebrews, who in turn were the first to discover the value of oak bark in tanning. Homer's *Iliad* describes the oldest form of good tanning, the "shamoying" process, whereby the pores of the hide are opened by repeated washings and thereafter oil is forced into it by beating and rubbing while the hide is stretched and staked out, the whole taking about two hours' work. The Romans put into practice the same principles in processing hides as we do today. Our present methods of making hides and skins into leather are, therefore, the result of tens of centuries of experience and forgotten failures.

The importance of hides and skins is seen by the fact that historically they were the first by-products of meat-packing. Under ordinary conditions it rarely pays to breed and raise an animal solely or mainly for its skin. But after the carcass is disposed of, hides and skins provide the largest source of income to the slaughterer. In the case of cattle, about $6\frac{1}{2}$ per cent of the live weight is in hides. While the proportion of the value of the hide or skin varies with the species, with the value of meat, and with market conditions, it is usually reckoned at 10–12 per cent of the gross value of the total products. The annual value of hides and skins produced in the United States is estimated by some authorities at one-third of the value of the other by-products of the meat industry.

In 1925 there were tanned in this country about 19,782,000

hides and skins, which represented a small decline of 1 per cent from 1924. Of this supply, 77 per cent went into shoe leathers, 11 per cent into fancy bookbindings and kindred leathers, 7 per cent into glove leather, 4 per cent into belting, bag, harness, and upholstery leathers, and 1 per cent into miscellaneous leather. The supply of different kinds of hides and skins in the United States for 1925 and 1926 shows the size of the trade (see Table III).

TABLE III

	1925 (Number)	1926 (Number)
Cattle hides	16,895,373	16,683,720
Calf and kip skins	13,172,583	16,061,435
Goat and kid skins	46,783,486	52,691,788
Sheep and lamb skins	45,771,446	38,003,341

Thus the yearly supply of cattle hides in the United States averages nearly seventeen million. Only three-quarters are produced from domestic cattle slaughter, however, while the remainder are imported. Of the domestic supply, about two-thirds are packer hides, taken off at plants having government inspection, while the others are country hides.[1]

The part that the United States plays in the international hide trade is primarily that of an importer. The following table indicates the leading countries in the international hide business:

Principal Exporting Countries	Principal Importing Countries
Argentina	United States
British India	Germany
Brazil	United Kingdom
China	France
Uruguay	Belgium

The chief sources of the hide imports into the United States are: Argentina, Canada, Uruguay, Colombia, Cuba, France, Venezuela, Mexico, Brazil. From these countries and some others the United States received in 1925 a total of 362,288,000 pounds,

[1] For a recent authoritative detailed study of hides and skins, see John Arnold, *Hides and Skins* (A. W. Shaw Co.), to which mine of information the present writer acknowledges his indebtedness in preparing this chapter.

of which the total value was $96,746,000. Table IV shows the principal imports:

TABLE IV

IMPORTS INTO THE UNITED STATES OF PRINCIPAL KINDS OF HIDES AND SKINS BY LEADING COUNTRIES OF ORIGIN

1926	Pounds	Value
Cattle hides:		
Total	150,419,274	$22,102,591
From:		
Argentina	78,471,109	12,236,840
Canada	37,216,853	4,331,058
Uruguay	7,180,355	1,182,164
Colombia	4,994,649	959,235
France	2,276,968	451,863
Calf and kip skins:		
Total	45,195,140	11,587,504
From:		
Canada	9,145,726	1,538,674
France	5,472,013	1,505,039
Germany	5,396,944	1,553,669
Sweden	3,591,157	916,186
Switzerland	2,006,477	579,551
Sheep and lamb skins:		
Total	59,187,888	18,794,878
From:		
New Zealand	16,912,499	5,032,293
Argentina	10,011,464	2,812,012
United Kingdom	8,742,715	3,192,122
Uruguay	3,142,206	844,946
British South Africa	3,111,329	1,052,375
Goat and kid skins:		
Total	87,604,705	39,084,122
From:		
British India	36,899,123	14,099,940
China	12,452,924	6,020,387
Mexico	4,665,881	1,806,428
Brazil	4,114,959	2,539,140
Argentina	3,907,940	1,358,991

Since 1900 there has been a marked increase in American hide imports: (1) The removal of the hide tariff in 1909 greatly stimulated imports up to 1914, and (2) The trade disturbances due to the war further stimulated the hide and leather business until the restriction of European buying power made America the best outlet.

The annual world-production of cattle hides and calf skins is estimated at about 91,000,000 pieces. The collective consumption

of the four chief leather-manufacturing nations is about two-thirds of this total. At the present time about 120,000,000 sheepskins are produced throughout the world, and about 47,000,000 goat and kid skins.

This world-production and international trade in hides and skins has been subject to severe fluctuations during the last two decades. Volume of hides and skins is falling behind in proportion to the probable future demand, though the world-supply may be increased through the stocking and grazing of areas now vacant, fuller stocking of those partly used, substitution in some areas of breeds yielding better raw stock, recovery of more fallen stock,[1] improvements in take-off and cure, and in better care and handling of animals—in any case a slow process.

In the packing business hides and skins are divided, technically, into three general classes, according to size, as follows: Hides, kips, skins. Of these classes, hides comprise the pelts from large and fully grown animals, ranging from cattle to walruses. The leather made from them is thick and heavy and can be used for shoe soles, machinery belting, harness, and other purposes where stiffness, strength, and wearing qualities are needed. When split they are used also for shoe uppers, and bag, case, strap, automobile, carriage, furniture, and upholstery leathers.

Kips are the skins of immature or undersized animals of the foregoing species. Skins are the pelts of small animals, such as calves, sheep, and goats. These kips and skins yield a lighter leather than hides, suitable for a great variety of purposes, such as uppers for shoes, bookbinding, pocketbooks, gloves, and fancy leather. Pelts vary in thickness and texture in different parts, being thicker on the neck and butt than on the flank and belly. Pelts of the same species vary greatly according to the climatic and housing conditions under which the animals are bred, raised, and fed.

The hides and skins used in commerce include those of cattle, calves, sheep, pigs, horses, and goats. It should also be mentioned

[1] Fallen stock comprises hides secured from animals dying from natural causes on farms and ranges.

that a large amount of leather is produced from deer, kangaroo, buffalo, dog, seal, walrus, shark, porpoise, whale, sturgeon, alligator, crocodile, lizard, and other animals.

Cattle Hides

The commercial classification of cattle hides in the United States is complicated because of the size of the country, the strict standards of the tanning industry, and the diverse origin of the herds of different regions. The primary distinction is between *packer* and *country* hides.

The classification of packer hides is as follows:

				Specifications
Packer	Steers	Natives	Spready	Minimum width, 6′6″
			Heavy	Cured weight....60 lb. up
			Light	Cured weight....50–60 lb.
			Extreme light	Cured weight....25–50 lb.
		Branded	Butt branded	Cured weight....50 lb. up
			Colorados (side branded)	Cured weight....50 lb. up
			Heavy Texas	Cured weight....60 lb. up
			Light Texas	Cured weight....50–60 lb.
			Extreme light Texas	Cured weight....25–50 lb.
	Cows	Natives	Heavy	Cured weight....55 lb. up
			Light	Cured weight....25–55 lb.
		Branded		Cured weight....25 lb. up
	Bulls	Natives		Cured weight....25 lb. up
		Branded		Cured weight....25 lb. up
	Calves	Kips		Cured weight....15–25 lb.
		Packer calves		Cured weight....Under 15 lb.
		Slunks*		Sold by the piece

* Slunks are unborn or prematurely born animals.

Packer hides.—Packer hides are taken off uniformly, are sorted, cured, and stored under standard conditions, and are usually available in such numbers that purchasers may secure several thousand of one grade of hide. Packer hides are divided into the

following subclasses: steers, cows, bulls, and kips. Steers are further subdivided into native, Colorado, and Texas. Native steers come from the farming states and are unbranded; the others are largely range cattle, Colorados carrying brands on the side, and Texans being branded on all parts. Texas hides are small, thick, and plump, and are favored for sole and belting leather. Colorados are spreadier and less plump. Both bring lower prices than the native stock, depending on the size and number of brand scars.

Cows, bulls, and calves that come on the market are chiefly native, except for the fall run of branded range cows. In the case of steers, cows, and calves, there is a classification according to the run of weights; but in bulls, the hides are mainly taken from old and heavy animals.

The average weights of the different classes of hides follow: heavy native steers, 62–65 lb.; light natives, 54–55 lb; extreme light natives, 40–45 lb.; butt branded, 60–65 lb.; Colorados (side branded), 60–65 lb.; heavy Texas, 63–65 lb.; light Texas, 55–56 lb.; extreme light Texas, 40–50 lb.; heavy native cows, 60 lb.; light native cows, 42–48 lb.; branded cows, 43–55 lb.; native bulls, 70–85 lb.; branded bulls, 70–85 lb.

Hide Selections and Price Reductions

When buying hides the purchaser wishes to obtain specific classes suitable for the kind of leather he produces and that is demanded by current market conditions. He is entitled to certain general reductions in price for specific defects. For example, he usually secures a reduction of $\frac{1}{2}$ to 1 cent per pound for hides carrying a considerable tare in the form of manure or other dirt. If the hides come from an animal infested with the grubs of the ox-warble, the buyer is entitled to a reduction of 1 cent a pound, in case five or more grub holes are found in the hide. The grubs are most frequent in the hides of animals slaughtered in the spring, but the grubbing privilege is exercised over different periods of the year, depending on the geographical origin of the cattle. It is usually exercised from November 1 to May 31. Kosher-killed cattle, which provide

from 10 to 25 per cent of heavy hides, are subject to a $\frac{1}{4}$–$\frac{1}{2}$ cent per pound reduction in hide value, due to the deep cut in the throat. Similarly, cut or scored hides, accidentally damaged in skinning, are reduced about 1 cent a pound, and usually include from 3 to 4 per cent of the total production.

There are many sex differences which develop in hides. Cow hides are thicker through the hindquarter and lighter in the forequarter, while bull hides are quite thin behind and very thick over the shoulders. Steer hides are intermediate, but are heavier behind than the bull's hide, and are wider. Hides are thicker in winter than in summer, but the shrinkage due to cure is greater in summer than in winter hides. Without going into salt, summer hides will stand up only two days, while winter hides will stand up three days. Large packers grade hides as they go into the salt, but smaller packers grade as the hides come out.

While Texas hides usually make the heaviest sole leather, they suffer in value because of brands, and when tanned into sole leather wear out very rapidly. Cattle naturally hornless usually throw a heavier hide in proportion to their weight than do horned cattle. Bull hides are heavier than steer hides, and steer hides are heavier than cow hides. Among breeds of cattle, Herefords, Brown Swiss, and Aberdeen-Angus throw the heaviest hides, with Holstein-Friesians and Shorthorns next.

Some of the more important classes of hides are as follows:

Native steers.—Steer hides free from brands are graded according to weight, as, e.g., heavy hides, above 60 lb.; light hides, between 50 and 60 lb.; and extremes, between 35 and 50 lb. Heavy hides are usually kept separate and sold for belting leather. Light hides sell for 1 cent less per pound, and extremes for 2 cents less, than heavy hides. Kosher hides are included in regular lots, but are sold for $\frac{1}{4}$ cent reduction. The grubbing privilege in native steers is granted from January 1 to May 31.

Spready hides.—Native steers going into this selection must be perfect in all respects and free from brands and grubs. In the West, the measure of a spready hide must be 6 feet 6 inches across the shoulders just back of the brisket, while in the East the meas-

urement is 6 feet 8 inches. Hides of this class are generally used for furniture and automobile upholstery. As winter-killed hides are likely to be very grubby, the tanner prefers to buy stock killed from June to January. These hides bring top prices today, although a few years ago they brought less than others. Spready native cows must be perfect and measure 6 feet 4 inches across the brisket. They go into the same trade as spready steers.

Texas steers.—These hides are from branded range cattle and, on account of plump condition, find a ready market in the sole-leather trade. The cattle themselves are grown more slowly than in the corn belt, and the hide develops more in thickness and weight in proportion to the animal's body. Due to good breeding, however, the quality of skin is improving and the weight rapidly decreasing, which is creating a shortage of hides of this type produced in the United States. Grubbing privilege extends from November 1 to May 31.

Colorado steers.—The hides from Colorado steers are side branded, either on one or both sides. As a rule they are more spready but have a more spongy feel than Texas hides. The grubbing privilege extends from December 1 to May 31. They are selected as heavies, over 60 lb.; lights, 50–60 lb.; and extremes, 25–50 lb.

Cow hides.—The so-called "native cow hides" are free from brands, and are graded as heavies when over 55 lb., and lights when under 55 lb. Branded cows, on the other hand, are not classified by weight, but are sold on the basis of actual poundage. Both selections are grubbed from November 1 to June 1, with the usual allowance of $\frac{1}{4}$ cent off in the case of kosher hides.

Bull hides.—The native bulls are free from brands. They are not grubbed, and are usually sold flat. Branded bulls are also sold flat and not grubbed. Bull hides are recognized by their tough pate, thick and ribby neck, and their butt. As a rule spready bulls are not sorted out. Some tanners, however, prefer selection, and in such cases the sorting is done by the broker.

COUNTRY HIDES.—Green salted hides which are not taken off by large packers are known as country hides, but they may come

from the same kind of cattle as those killed by packers. The principal difference is in the method of take-off, which is certain to be un-uniform, and which frequently results in bad cuts, scores, and poor patterns. These hides are salted lighter, or sold green to small collectors who sell them direct to tanners or to large dealers by whom they are sorted into grades and weights. Defects of country hides include grubs and hair-slips. Badly damaged hides may have to be converted into glue.

Country hides are usually quoted somewhat as follows:

Country	Heavy	Steers	60 lb. up
		Cows	60 lb. up
	Buffs		45–60 lb
	Extremes		25–45 lb.
	Bulls		60 lb. up
	Branded	Side-branded country packer	25 lb. up
		Side-branded country	25 lb. up
	Calf-skins	Kips	15–25 lb.
		Calf	8–15 lb.
		Light calf	under 8 lb.
		Deacons	under 7 lb.
		Slunks	sold by the piece

Small packer hides.—In recent years there has been a growing tendency to separate from the run of country hides a class taken off with more than usual care by small killers outside of federal inspection. These are known as "small packer" hides, and they command a sufficient margin of price over the average country hide to pay the local killer for using more careful methods of take-off. The small packer hides are salted in the same manner as those of large packers. However, small packer hides are graded only into unbranded and branded steers, cows, and bulls. The chief distinction between these hides and large packer hides is that the former do not afford such a wide classification and selection.

Country hides have a geographical classification due mainly to custom, though resting partly on the breed, on peculiarities in the take-off and on the prevalence of defects. Country hides are not

usually classified for brands, but those from the South are selected for ticks and those of the Southwestern states are graded for dry stock. Otherwise a green salted cure is assumed.

Calfskins.—All skins under 15 lb., except slunks, are sold as calfskins according to commercial classes, which follow: (1) Veals (a class of milk-feds; 12 lb. green, 6 lb. dry). (2) Calfskins proper (medium and light weight. Skins which have the basic qualities of milk-fed stock because taken from animals not yet weaned. Lower weights, 5 lb. green and $2\frac{1}{2}$ lb. dry). (3) Grassers (a class of skins from animals that have ceased to be fed on whole milk). (4) Slunks and deacons (skins from stillborn and unborn calves, running 4 lb. and under green, and 2 lb. and under dry).

Sheepskins.—Sheepskins are more numerous than all other pelts converted into leather. Quality in sheepskins depends upon the environment and methods of sheep feeding. Soft-wooled skins have a fine grain, while long-wooled skins show a coarse tough grain. Recently, the supply of sheepskins has been decreasing and their cost has increased greatly. The various types of sheep and sheepskins follow:

a) Heavy-wooled types: (1) Fine-wooled or merino sheep. (2) Coarse or open-wooled sheep.

b) Intermediate type.

c) Inferior-wooled types: (1) Low-wooled sheep. (2) Hair sheep, or cabrettas.

d) Mixed types.

Sheepskins are relatively low in value, and leather made from them is not very resistant to tension or abrasion. Therefore, they are converted into leathers having wide distribution due to their low cost and their suitability for special purposes, rather than to their durability. The value of sheepskins is decreased by frequent imperfections which cause loss to tanners. The worst enemies of sheep from the standpoint of the skins are the flies or parasites which transmit diseases, producing such afflictions as gid, louping ill, or scab, and blowflies and ticks.

Pigskins.—Though an interesting product of the meat-packing industry, pigskins constitute but a minor part of the hide and

skin trade. The importance of pigskins is often exaggerated by the layman. Probably not more than 250,000 whole pigskins are used in the United States each year, or but little over $\frac{1}{2}$–1 per cent of the total annual hog slaughter. There are no reliable data regarding world-production and consumption of pigskins. The leather made from pigskins is distinctive in appearance, and because articles made from it are conspicuous, many do not realize the limited range of its commercial uses, in spite of a growing demand for the strip across the shoulders and the bacon strips.

The main reasons for the limited use of pigskins are: (1) Marked variations in quality. (2) Pigskins have little protective covering and their grain is easily injured by scratches. (3) Flaying of hogskins is difficult; and (4) flaying impairs the quality of ham and bacon when smoked.

Tanner Classification of Hides

There are five conditions in which the hides of animals reach the tanner. These are: (1) green, i.e., fresh from the animal; (2) green salted, i.e., salt has been rubbed on the flesh side; (3) dry salted, i.e., the hide or skin has been rubbed with salt and dried; (4) pickled, i.e., cured in a salt solution; (5) dry, i.e., stretched to cure on boards in the sun.

Green salted cattle hides.—Green salted cattle hides are salted on the flesh side with common salt. The hides are then piled down to cure in such manner that the slope is toward the center. In this way the brine is retained and the cure materially aided, a process requiring at least thirty days. They are left in the pack until sold to a buyer. When sales are delivered, the hides are removed from the salt bed, shaken over a horse (a wooden frame), then spread out on the floor for inspection on both hair and flesh sides for cuts, brands, and other defects, following which they are bundled and tied.

New process cure of hides.—One of the modern methods of curing hides is the washing in and use of pickle instead of following dry-salting methods. These hides are not salted down after being pickled. Some of the advantages of the new pickle method are

uniformity and rapidity of cure, and elimination of manure, blood, and dirt. This method assures leather free of stains.

Dry or flint hides.—The simplest form of cure is to dry the hides in the open air, exposed to the action of both wind and sun. Too rapid drying often results in the contraction and hardening of the surface. The moisture, not being removed from the middle section, gives rise to bacterial action injurious to the hide substance. Unfortunately this type of damage cannot be detected at time of purchase.

The best dry cures are obtained under comparatively low temperatures and good circulation of air. The higher the thermometer, the harder the stock and the longer the period of time necessary to soak it back into flexibility.

Dry salted hides.—Dry salted hides differ from dry hides in that first a coating of salt is applied to the flesh side, and, after being stored in packs for some time, they are spread out and allowed to dry in the sun. Dry salted hides, unlike dry hides, do not contract during drying and are much more readily softened when soaking.

Trade Characteristics of Hides and Skins

The price peculiarities of hides and skins are due in general to the fact that they are by-products. The most important peculiarity is that the supply fails to react in a prompt and even fashion to the demand. While an increased demand for raw stock might be supposed normally to result in a willingness to pay more for the supply, the fact is that this demand cannot bring out a large supply of hides unless there is at the same time a greater demand for the primary livestock product, meat. Many times such increases and decreases in demand correspond, but more often they do not. Reduction in hide price does not result in a withdrawal of a proportionate part of the supply from the market. Meat animals are killed in response to the demand of the consuming public, but hides and skins must be taken off, regardless of whether they are in demand.

Hides and skins, as by-products, have disadvantages for deal-

ers, consumers, and producers because abnormal changes introduce an unfavorable element of speculation into a business with a slow turnover. The fact that hides and skins are by-products helps to make impossible artificial price support during depression, to discourage import and export duties, and to restrict leather-substitute competition. The lack of correspondence between hide supply and demand results in certain sharp variations in prices which are primarily cyclical, but not sufficiently so to enable prices to keep the market in balance. The trade in hides and skins involves the tying up of capital in such a manner as to make frequent and severe price changes harmful. Therefore, efforts have been made to avoid such unfortunate periods. While some system of stabilizing hide markets and preventing these price changes by hedging has been advocated, a satisfactory method has never been worked out because hide production is too widely dispersed over the world to permit large-scale buying long in advance of delivery. Furthermore, the movement of hides in international trade is too fluid.

The attempts during the World War to regulate hide prices were far more ineffective and far more disastrous in result than in any other commodity. The primary difficulty lay in the early efforts to change from an open to a controlled market, but the greatest losses were sustained in the unexpected upward movement in hide prices following the period of government control. Certainly conditions were never more favorable than under the restricted production and excessive demand of the war period. If this war-time effort to regulate prices was unsuccessful, any attempt today, with no governmental authority and control to be of assistance, would be unsuccessful, and the chances for failure are so clear that there is no probability of such action.

Spreads between prices of different classes and grades of hides and skins are due primarily to variations in quality and suitability for leather making. But a difference should be noted between packer and country hides. There is rarely any fixed spread between packer hides, while between one class of country stock and another there is a tendency toward rigidity in price margins.

These margins do not take account of differences between stock and recognize improvements, because the large scale of the international hide trade prevents accurate price margins on the small lots in which country hides are sold.

Units of quantity, though always implied in quotations, are rarely specified. They vary with the species of hides or skins and with the area of production.

In the case of cattle and buffalo hides the unit is usually a weight—the pound or kilogram. In the case of hides or skins in international trade which have not yet been exported from the producing areas, there is used a local weight or some variation, such as the half-kilo (demikilo), of 1.123 pounds. In the domestic trade the conventional quotation is per pound.

Other hides and skins are quoted thus: calfskins, sometimes by weight and sometimes by the piece; sheepskins, by weight or by piece, dozen or hundred according to the market; goatskins, by weight or by piece, dozen, or hundred, or by the bale containing an arbitrary number of skins; horsehides, and most of the minor classes, by the piece.

The processing and preliminary handling costs of hides represent but a small percentage of quoted prices or delivered costs. For example, an American packer steerhide of average weight and best quality, selling for about $11.50 at its place of production, costs, on the average, 50 cents to 75 cents for curing and shipping. Transportation charges are an item in costs, but, up to 1,000 miles by railroad and 2,000 to 3,000 miles by sea, do not differ greatly. Generally speaking, a hide can be shipped from Chicago to New York at about the same rate as from New York to Great Britain.

Certain specifications are used for satisfactory hide and skin price quotation. While not all of the following characteristics are specified on the same stock, some being implied in many cases, these elements must all be taken into account at one time or another in defining adequately a type or lot of hides and skins. These factors are: the species; the breed or variety; the region or country of origin; the place of take-off; the place of primary marketing; the type of producing establishment; mature or im-

mature stock; distinctions of sex, size, weight; method of cure; trim; branded or clear; grade; seasonal condition; presence of foreign substances; water content, and shrinkage.

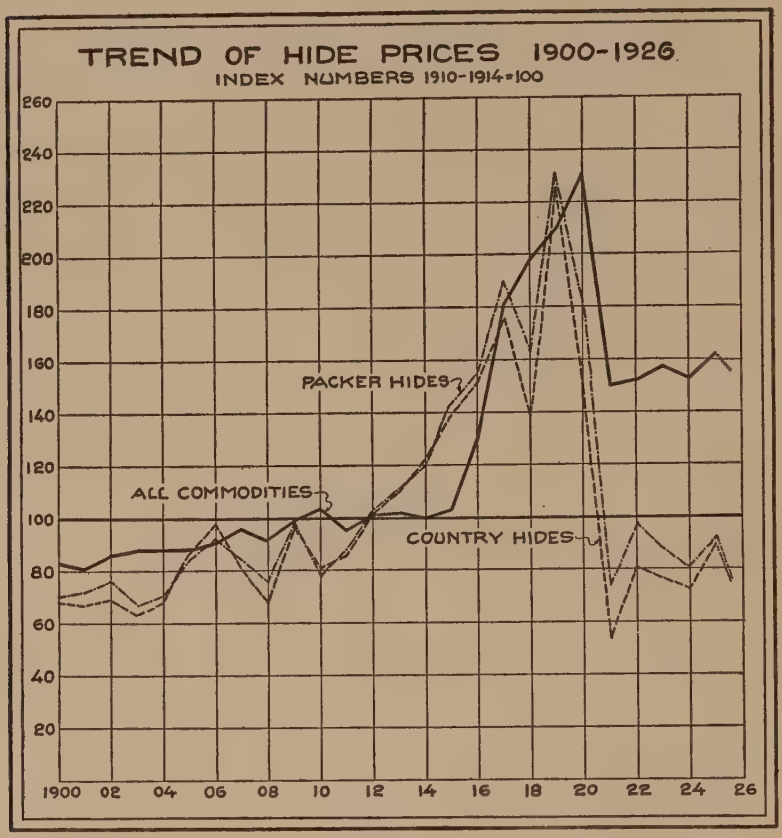


FIG. 2

HIDE-PRICE HISTORY.—From the beginning of this century until the outbreak of the war, the trend of hide prices was moderately upward. Furthermore, prices of packer and country hides very nearly paralleled one another. The inflation and post-war deflation caused the violent fluctuations in prices so strongly brought out in Figure 2. Another significant change took place in the relative value of packer and country hides, as the latter since

1915 have lost ground compared with the former. This illustrates the economic principle that higher-grade products resist price de-

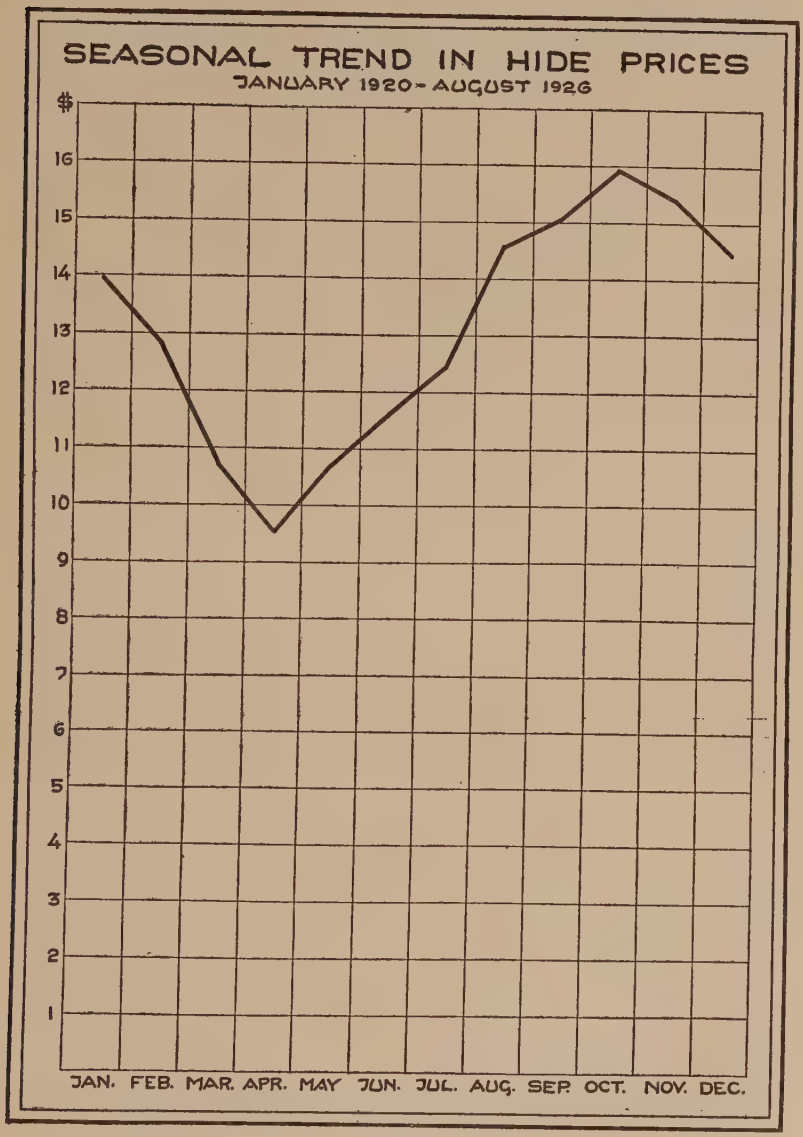


FIG. 3

clines more effectively than lower grades. Before 1912, hide values were almost consistently below the all-commodity curve, although only to a moderate degree. From 1912 into 1919 the hide curves ran above the all-commodity line, with the exception of the year 1918. Since 1919, the condition has been reversed, indicating in recent years an extremely low purchasing power of hides. During the first decade of this century hide values underwent rather wide

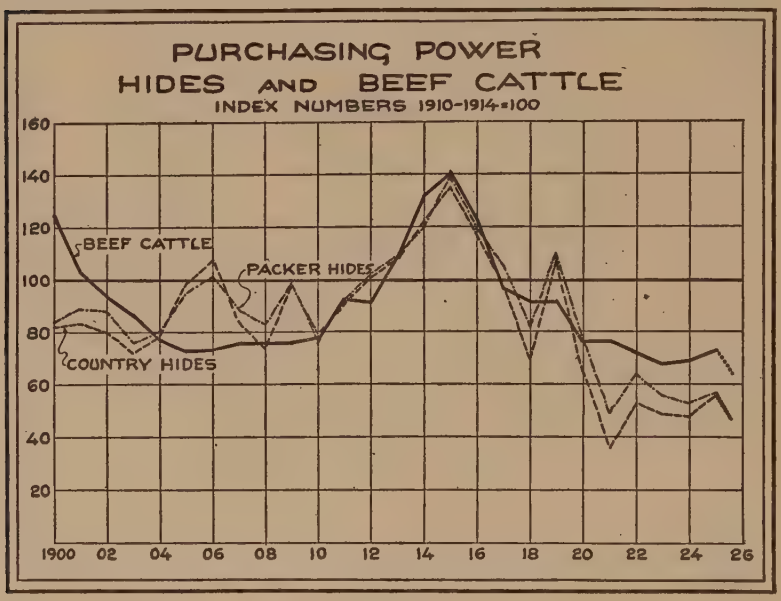


FIG. 4

fluctuations. From 1910 forward the purchasing power mounted regularly to reach the high point in 1915. This increase in value cannot be accounted for by war conditions alone, since it was well under way before the outbreak of hostilities. Shortage of domestic production was principally responsible. During the years of most intense warfare (1916–18), furthermore, hide purchasing power receded, followed by a short recovery in 1919. From that year on, hide values suffered far more severely than those of most other commodities, until they became temporarily stagnant, with levels in 1926 showing only half of the pre-war purchasing power.

Besides the general trend from year to year, seasonal fluctuations in hide values occur regularly within each year. These variations are indicated by graphing the hide price for each month on the basis of a six-year average (1921–26). This curve reflects adjustments on the basis of quality. From December to April prices decline, as the incoming supply consists largely of winter-type hides—long-haired and grubby. From April to November hide

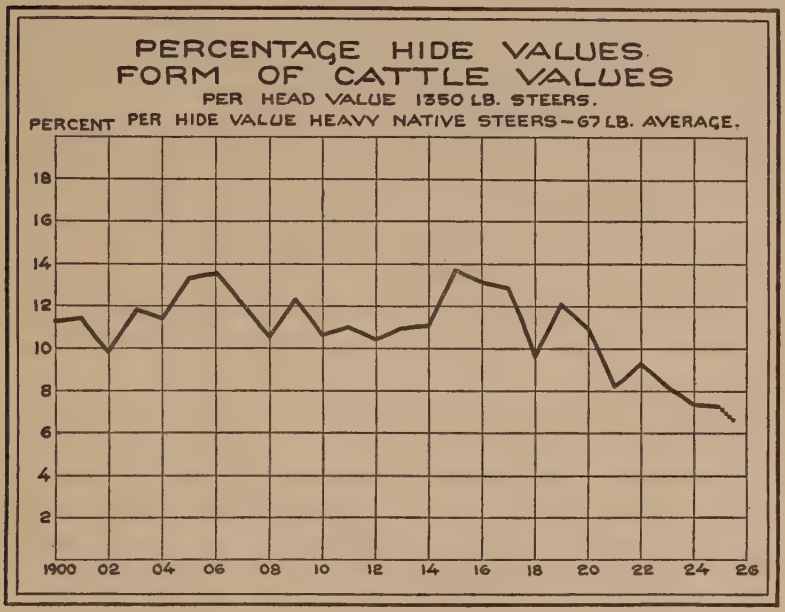


FIG. 5

prices move upward as the quality improves. It is significant that the bearish effect of the increased supply of packer hides at this time of the year does not offset the bullish effect of quality.

The discussion in recent years of re-establishing the tariff on hides makes the relation of the value of hides to the total value of steers a factor of importance in the prosperity of the cattle industry. Figure 5 presents the percentage of the value of 1,350-lb. steers which hides have formed for the last quarter of a century. In general, the trend is downward, reflecting the fact that con-

ditions in the hide business have been more unfavorable than in the beef industry, although there are two favorable periods in 1902–8 and 1914–17. Nevertheless, in the opinion of many students of the industry, this downward trend will stabilize with the present relationship as a low point.

METHODS OF HIDE MARKETING.—Packers and other producers of hides who do not tan their own supplies market them through various channels both in the foreign and domestic trade. Among the more important methods of domestic marketing are the following: (1) Through a few direct representatives of large tanning corporations. (2) Through hide brokers who buy on a commission for several tanners. (3) Through dealer companies which buy standard selections of hides and regrade them. (4) To tanning companies which are subsidiaries of the packing companies themselves. (5) Through collectors of country hides and skins. Hides are always sold to tanners on a spot-cash basis.

The usual method of domestic sale is ex-slaughter-house or ex-warehouse, which in practice often means f.o.b. cars or rails. If a producer or a dealer takes further care of a shipment, it is normally for the account of the customer. In international trade, however, most quotations are c. & f. (cost and freight). In general, freight on wet-cured hides and skins is based on the net weight, which is mainly a matter of custom. Hides and skins are in some cases sold by weight, in other cases by the piece, dozen, or by the bundle or bale containing a customary number of pieces. When sales are on the first of these bases, as is the rule with all cattle hides, buffalo hides, with most calfskins, and with some sheepskins and goatskins, they are made (with rare exceptions) on the *net* weight. This means that due allowance must be made for the matter of tare. The following substances are included in the commercial tare of hides and skins: (*a*) the limited quantities of packing, wrapping, or baling materials required; (*b*) the salt used in curing wet stock, together with loose foreign matter, such as manure, dirt, etc. Exclusion of some foreign substances from the commercial tare for which allowance is made is often limited by a guaranty that they will not exceed a certain proportion, usu-

ally 3 per cent of the gross weight of a shipment. The actual percentage of shrinkage allowed or guaranteed varies with distance of shipment, or length of time in transit. The total "shrink" from the original weight of a green or wet salted hide or skin to the final delivery may be as high as 35 or 40 per cent, or as low as 5 or 7 per cent, with an average of 15–20 per cent.

In packing and shipping hides and skins, dry and wet stock are taken care of differently. While dry stock is sometimes shipped loose, it is usually shipped in bales, ordinarily unwrapped. The weight of bales of dry hides or skins varies from 100–150 lb. to 1,500 or 1,600 lb., and the size likewise, while the number of pieces in a bale may be as low as 7 or 8, or as high as 500. Properly dried and baled hides and skins will stand a great deal of rough handling without much damage. Though damage is rare in land transit, it may be caused by sweating, heating, contact with other cargo, or fresh-water damage. In nearly all cases, green and wet salted hides and skins are shipped in bundles of from 1 to 5 pieces, each folded separately to retain the salt and the saline liquor formed in the process of cure.

HIDES AND THE TARIFF.—The tariff plays some part in setting hide prices, but the international market is free, except that at times the tariff has exerted a minor influence. During and just after the war there was a tendency, only now subsiding, to increase trade restrictions. However, import duties on hides and skins are rare because (1) they are the raw material of large industries which are located in the most important consuming countries; (2) they are by-products whose supply is unrelated to demand for leather; and (3) the leather-substitute industry provides such severe competition that hides can probably stand no artificial boosting of prices without losing some of the outlets in the leather trade which they now possess.

A hide import duty is ineffective in increasing prices because the commodity is a by-product. A duty must have a protective effect. Advocates of a hide duty believe that it would increase consumption of domestic hides, but the supply of hides and skins is determined by the primary products of livestock production

(meat), and not by the prices of hides themselves. It is interesting to note that the sole modern instance in which an import duty has been levied on hides, or has come very near enactment, is that of the United States. A duty was imposed in 1897 which was only taken off in 1909, and in 1922 was very nearly reimposed. In placing a tariff on hides it is difficult to avoid preferential treatment in duties levied on certain varieties and grades.

There are some legitimate restrictions now in force on hide and skin imports into the United States, such as those which prevent the spread of animal disease, especially anthrax, foot-and-mouth disease, and rinderpest. Permanent regulations are in force, because it is impossible to exercise control over epidemics in foreign countries. Today the American hide and skin importer has three alternatives under the present import regulations, viz., (1) to obtain a certificate that a shipment of hides or skins originated in a district in which anthrax was not prevalent and the other two diseases did not exist; (2) to obtain a certificate that such a shipment had been disinfected before exportation to the United States; and (3) to arrange for handling it under a tanner's agreement.

Hide Handling

After the hide is dropped from the carcass to the floor it is thrown into a chute leading to the hide cellar. Here the hides are sorted into different grades, classes, and weights, each grade being assembled in its respective pack. The workmen in the hide cellar are usually about two hours behind the killing gang, so that the animal heat may be out of the hides before salting. As the men in the cellar gang receive the hides, they split the ears and then pile them down flat with the flesh side up. Over each hide is sprinkled about 60 pounds of rock salt, and the outside edges of the hides in the pack are turned up in order to retain the pickle in the stock and hold the pack in shape. The piles are low and flat, to prevent drying out. After the back edge and corners of the pack are put in, the sides are built up. When the back and sides have been established, the spreads in the centers are put in. This is done in such a manner that the heads of the skins are pointed

HIDE INSPECTION FOR SALES

BUNDLING HIDES FOR STORAGE IN HIDE CELLAR

toward the middle. As the spreads are placed in, the front is built up. Hides packed in the proper way will keep one or two years, but in practice they are seldom left for this length of time, thirty days being the usual period. If hides remain in the pack too long, salt stains result. In putting down hides the work is done by a gang consisting of two spreaders, one salt thrower, and a salt trucker, and it usually handles about forty hides an hour.

To obtain the best results the first step in tannery operation is soaking and fleshing to clean the skin, remove the salt, and restore the skin to its original size, shape, and soft permeable condition. This takes some three days, during which there is a daily change of fresh cold water. Liming follows soaking, which has the effect of loosening and separating the hairs and glands from the skin. The skins are put into a vat equipped with a paddle wheel, to keep the liquor well stirred, and are treated with lime-water containing a small percentage of sodium sulphide. The lime not only loosens the hair, but swells and splits up the fiber, and so fits it to receive the tannage.

The hide is then ready for dehairing and scudding. Dehairing is accomplished in a machine in which the hair side is forced against a revolving roller set with blades, which scrape off the loose hair and epidermis. After this comes the operation of scudding, in which the skin is put on a convex, wooden slab, known as a beam. A specially designed curved two-handled knife is then pushed down over the skin and to left and right, forcing the extraneous material from the pores and hair follicles.

In making sole leather, the hide is washed in soft water or weak acid solutions to cleanse it from the lime, and it then goes to the actual tanning process. For the softer leathers, more thorough treatment is needed to remove the lime and to soften the skin still further by solution and removal of a portion of the cementing substance of the elastic fibers. This process is called "bating," and is carried on in a paddle vat containing a dilute solution of pancreatic enzymes and a readily decomposed salt, e.g., ammonium chloride, to neutralize the caustic alkalinity of the skins. This bate liquor stops the swelling and rubbery effect of the lime and

makes the skins flaccid. Secondly, the enzymes act upon the elastic fibers of the skin, tending to dissolve them and to make the grain surface of the skin more readily extensible. An early process of bating was carried on almost entirely with a puer made from warm infusions of the dung of dogs or fowls. This was a most disagreeable process, and it has been almost universally abandoned in favor of chemical and bacteriological methods.

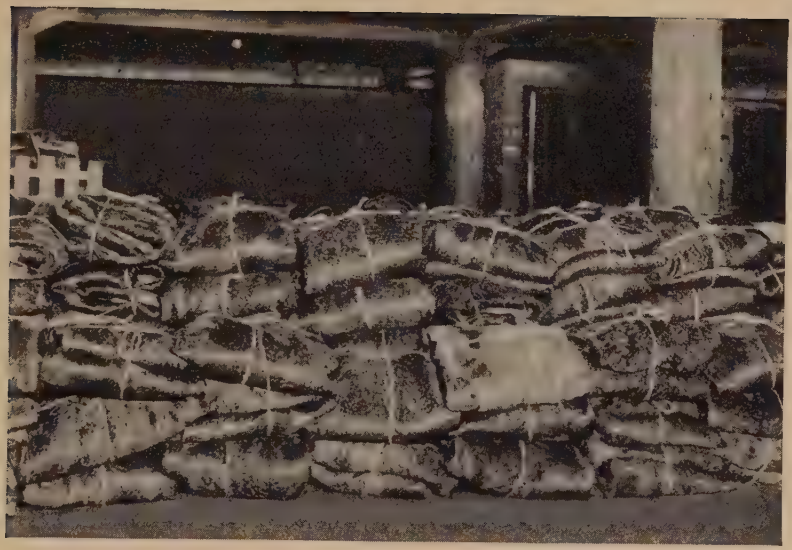
The bated hide or skin is ready to be tanned. Such bated skin putrefies easily, but when it combines with tanning agents, it gains resistance to putrefaction. The tanning liquids are made from many different barks, woods, nuts, leaves, etc., which have a high percentage of tannic acid. Among these are oak and hemlock, chestnut wood, quebracho, valonia, mangrove, sumac, gambier, myrabolans, divi divi, mimosa bark, wattle bark, and palmetto roots.

Tanning Operations

The term tanning process refers to the method by which hides and tanning agents are brought together and worked to produce the finished leather. All tanning is done through three distinct successive operations: (1) cleansing, dehairing, and softening hides preparatory to actual tannage; (2) tannage—by immersion, agitation and soaking in the tanning liquors; (3) finishing.

The primitive method of preserving hides and skins in a more or less pliable and imputrescible condition probably consisted in treating the pelt with the grease and brains of the animal itself, which were worked in by a process of pounding and stretching. Following this primitive method came the smoke treatment, and then developed the application of salts containing alum. The dyeing of this leather no doubt led to the discovery of a few vegetable tanning materials, but the last fifty years have seen the advancement of the industry to heights undreamed of, through the services of chemistry, physics, and bacteriology.

The substances entering into the manufacture of leather are of three classes: (1) raw hides and skins; (2) tanning materials (the substances which by their direct action convert the perishable animal fibers of hides and skins into comparatively perma-



HIDES STACKED AFTER INSPECTION, PREVIOUS TO SHIPMENT

SALTING DOWN HIDES IN PACKS

nent leather); (3) accessories (mainly chemicals that are required to prepare raw hides and skins to absorb the tanning materials, to assist those materials in their action, and to dress or finish the leather after it is tanned).

There are two main methods of tanning. Most leather made for the soles and heels of shoes and for machinery belting is vegetable tanned. The chrome tanning process, on the other hand, produces nearly all the leather for shoe uppers and glove leather, for other light soft leathers, and for fancy leathers. In both vegetable tanning and chrome tanning the preliminary processes of treating the hide, viz., cleansing, soaking, and dehairing, are practically the same. It is only in the strictly tanning process that there is a difference in method.

Today, leather without hair is desired, and therefore the preliminary processes aim to remove the hair and fit the hide or skin for tanning. The first step is curing, and its purpose is simply to preserve the hides until wanted. A hide acquires bacteria rapidly after flaying, and they decompose the leather-forming proteins of the skin. To prevent damage by bacteria, hides are salted until the solution retained by the skin is nearly saturated with salt, i.e., it contains over 6 per cent salt.

Tanning processes.—The vegetable tanning process proper consists in suspending the hides and skins head down in a vat with a weak infusion of tannins. Usually hides are cut down the back for this process, thus making two sides, though sometimes they are carried through as whole hides. Each day the skins are transferred to a stronger and fresher liquor, until in about ten days they are fully tanned. The tannin slowly permeates each fiber of the skin, converting the gelatin-like proteids (collagens) into a totally new material, leather. About sixty parts of tannin combine with one hundred parts of these proteids. The leather is then ready for the various finishing processes.

Chrome tanning is only a generation old. By this method the bated skins are pickled in diluted sulphuric acid and common salt and are then treated with a solution of basic chromium sulphate. The resulting chrome liquor diffuses through the skin and com-

bines the collagens and chromium to form chrome leather. The protein unites with the sulphuric acid always present in solutions of chromium sulphate and keeps the leather from becoming brittle. An advantage of chrome tanning in the making of light leather is that the collagen fibers combine with only 11 per cent as much materials by weight as in vegetable tanning. On the other hand, this explains the greater fulness and solidity of vegetable-tanned leather.

Following tanning comes fat liquoring and coloring to make the leather soft and pliable. The tanned skins are placed in a warm emulsion of oil in water and agitated. The oil globules cover the surfaces of the leather, and when dried the oil diffuses through the leather fibers, lubricating them and making the leather pliable and stronger. After being dyed, the leather is treated with various sizing materials, e.g., gelatin and casein, which give it a luster. These finishing operations are numerous and require skilled workmanship.

Uses of Leather

The tanning operations which have just been described deal only with sole and upper leather and machinery belting. Half of the hides in this country go into other products, e.g., harness leather, bags, straps, upholstery, and automobile leathers.

Since the beginning of history there has been little change in the main purposes for which leather is used. Naturally, certain uses have become obsolete or greatly decreased in importance, e.g., employment of leather for defensive armor, for clothing other than footwear, for containers for liquids (the "bottles" of the English Bible), for wall hangings, for drumheads, and for parchment and vellum. But none of these uses ever accounted for a large proportion of the hide and skin consumption of the modern Occident. Against them must be set the consumption of hides and skins for a few new classes of leather, particularly for transmission belting and mechanical specialties, the manufacture of which has been developed in very recent years.

The making of boots and shoes, which accounts for at least 80 per cent of the world's hide consumption today, has probably in-

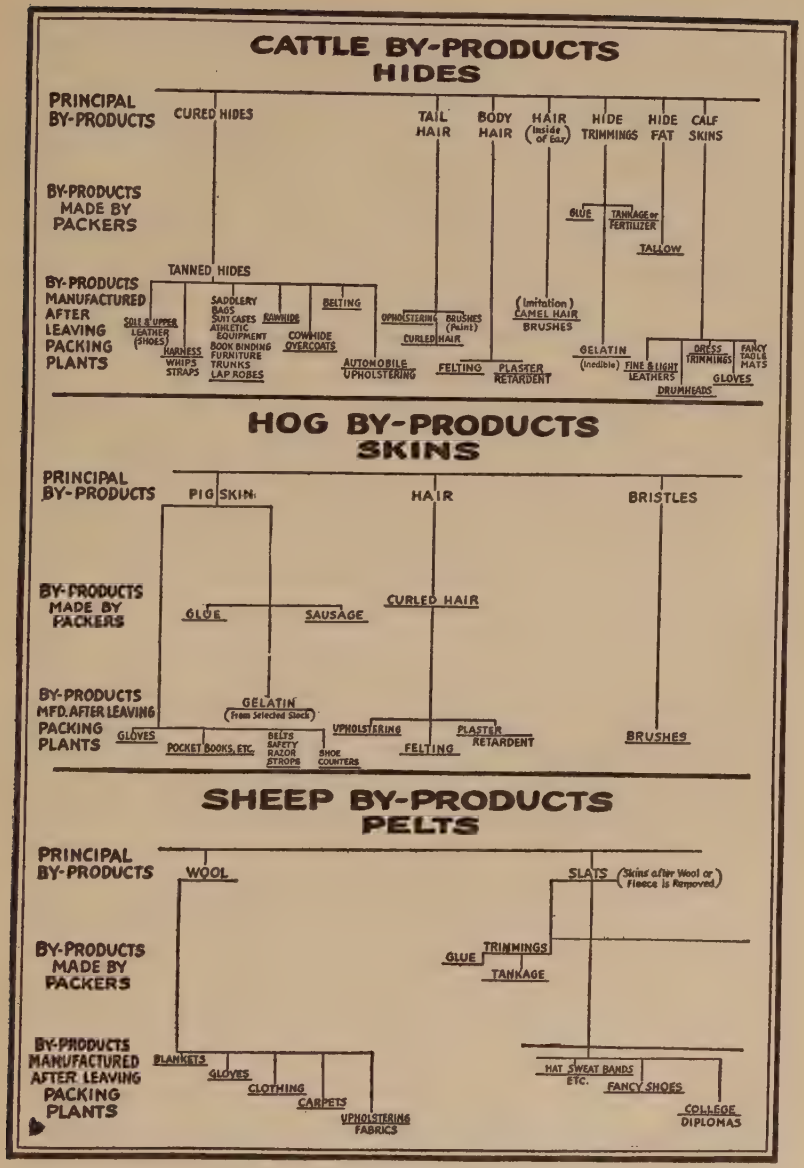

CATTLE BY-PRODUCTS
HIDES
PRINCIPAL BY-PRODUCTS
CURED HIDES
TAIL HAIR
BODY HAIR
HAIR (Inside of Ear)
HIDE TRIMMINGS
HIDE FAT
CALF SKINS
BY-PRODUCTS MADE BY PACKERS
GLUE
TANNAGE or FERTILIZER
TALLOW
BY-PRODUCTS MANUFACTURED AFTER LEAVING PACKING PLANTS
TANNED HIDES
SOLE & UPPER LEATHER (SHOES)
HARNESS WHIPS STRAPS
SADDLERY BAGS SUIT CASES ATHLETIC EQUIPMENT BOOK BINDING FURNITURE TRUNKS LAP ROBES
RAWHIDE
COWHIDE OVERCOATS
BELTING
AUTOMOBILE UPHOLSTERING
UPHOLSTERING
BRUSHES (Paint)
CURLED HAIR
FELTING
(Imitation) CAMEL HAIR BRUSHES
PLASTER RETARDENT
GELATIN (Inedible)
FINE & LIGHT LEATHERS
DRESS TRIMMINGS
FANCY TABLE MATS
GLOVES
DRUMHEADS
HOG BY-PRODUCTS
SKINS
PRINCIPAL BY-PRODUCTS
PIG SKIN
HAIR
BRISTLES
BY-PRODUCTS MADE BY PACKERS
GLUE
SAUSAGE
CURLED HAIR
BY-PRODUCTS MFD. AFTER LEAVING PACKING PLANTS
GELATIN (From Selected Stock)
GLOVES
POCKET BOOKS, ETC.
BELTS SAFETY RAZOR STROPS
SHOE COUNTERS
UPHOLSTERING
FELTING
PLASTER RETARDENT
BRUSHES
SHEEP BY-PRODUCTS
PELTS
PRINCIPAL BY-PRODUCTS
WOOL
SLATS (Skins after Wool or Fleece is Removed)
BY-PRODUCTS MADE BY PACKERS
GLUE
TRIMMINGS
TANNAGE
BY-PRODUCTS MANUFACTURED AFTER LEAVING PACKING PLANTS
BLANKETS
GLOVES
CLOTHING
CARPETS
UPHOLSTERING FABRICS
HAT SWEAT BANDS ETC.
FANCY SHOES
COLLEGE DIPLOMAS

FIG. 6

creased nearly parallel with the growth of population. But in modern times there has been an acceleration in this increase through the substitution of leather shoes for makeshifts of other materials on the part of the working classes of some European and Oriental countries, and through the adoption of such footwear, at least as a luxury, by many persons in tropical regions who had previously gone barefoot. Furthermore, the improvement in purchasing power of the average individual has permitted the gratification of many whims in show styles, especially for women, and has quickened the consumption of leather materially.

The chief classes of leather made from cattle hides, which for the most part explain their uses, are as follows: shoe leathers (sole, upper); miscellaneous (heels, toe-caps and counters, insoles, welts, linings, glove leather, bag and case leather, strap leather, harness leather, saddle leather, strop leather, suspender leather, moccasin and larrigan leather); skirting leather; collar leather; latigo leather; belting leather; upholstery leather; fancy leather; specialties (apron leather, buffing leather, carding and combing leather, hat-block leather, hydraulic leathers, lace leather, lithographic leather, picker leather [used in power looms], football leather).

Heavy cattle hides are used for the better grades of sole leather, for all but the lightest kinds of belting leather, for most harness leather, and for some specialties, chiefly mechanical, such as lace, picker, hydraulic, and lithographic leathers and mechanical rawhide. The spready hides used for upholstery leather mostly fall in this class.

Spready hides are not plentiful, due to the demand for baby beef rather than fully grown cattle. They may be used for a variety of purposes. Much their most important use is for upholstery leather for furniture and automobiles. The average measurement for the grain cuts or layers of all American upholstery leather is about 55 sq. ft. The area of an average sole leather hide is less than this, and of an upper-leather hide probably 35–40 sq. ft.

Light hides are used primarily for the lighter grades of sole

leather, secondarily, for some lighter harness and belting stock. They are also used for strap and shoe upper leathers, though these latter are largely made of cowhide.

Extremes are used for side upper leather, but they also go into light belting, light bag, case, and strap leathers, and into skirting, collar, and latigo leathers, a little heavy fancy leather, and such specialties as apron leather, carding leather, and low-grade strop leather.

Kips are generally used for shoe upper leather.

Splits are the resulting products from hides which are divided into two or more layers. The primary purpose of splitting is to obtain an even thickness through the layer of the hide having the largest area. The thickest part of a steer hide is over the butt or rump, and the thickness tapers off from that region toward the belly, flanks, and shoulders. Bull hides are thickest in the shoulders and neck, and goat skins in the shoulders. Sheepskins and horsehides are of uniform thickness and are seldom split. In actual practice hides are not often divided into more than three layers, although it is technically possible to obtain more than this number from very heavy cattle hides. Only one of the splits contains the grain, and it is known as a "grain split," "grain," or "skiver." The others are known as "flesh splits," "splits," or "fleshers." Hides are therefore usually split to get the largest size in the grain or skiver. Apart from pickled and rough splits, the principal commercial classes of splits are the partly finished *wax splits* for upper leather; the finished *vamp splits* for the same; the *flexible splits* for insoles of women's shoes; the *glove splits* for making leather for cheap utilitarian gloves; the *butt splits* of exceptional size which are taken from the butts of hides and are used largely for men's belts and fancy leather, and the *dope splits*, taken from upholstery leather and now used chiefly for cheap work in the automobile industry.

Leathers made from nearly all calfskins are tanned for shoe upper leather, primarily for men's shoes of the medium and lighter weights, but also for women's walking shoes. Calfskins are also made into fancy leather. Limited quantities are used for the bet-

ter grades of utilitarian gloves, and, along with a good many slunks and deacons, for shoe linings, tongues, stays, and facings. High-grade calf leathers are still considered excellent for book bindings.

The small remainder of calfskin consumption goes into a few specialties, such as whip leather, hat sweatbands, vellum, and drum leather used on the combing rolls of cotton machinery.

Sheepskins.—Sheepskins are made into a great variety of leathers. This is due to the many different qualities of the leading breeds or types, which make leathers as far apart as a cheap imitation morocco book binding, an ordinary "kid" glove, a chamois watch-case, and the upper of a cabretta shoe. There is an inverse relation between the quality of a sheepskin and its wool, since the value of a skin for tanning decreases as the value of its wool for spinning and weaving increases.

The more important leathers made from sheepskins and lambskins follows: shoe leathers (upper, linings; in color and black); miscellaneous (linings stays and facings); russets for soft soles and linings, collar-pads, aprons, and cabretta; glove leathers (gloves, mittens, sporting goods, and leather garments); fancy leathers (in all colors and grains for bags, pocketbooks, belts, and all leather novelties and book binding); specialties (apron, buffing leather, chamois leather, roller leather for cottonmill use); clothing leather, (shearlings, jerkin, hat sweatbands); meter leather, for gas meters and diaphragms; parchment; piano leathers (valve pouches, packing and bridles); roller leather.

Pigskins.—The main uses of pigskins and leathers from them are the following:

Saddle leather: It is quite widely used in Europe for high-grade saddles.

Fancy leathers: Both the resistance of its surface to handling and its distinctive and attractive grain adapt pigskin leather well for making pocketbooks, the better-wearing handbags, brief cases, small traveling bags, toilet cases, tobacco pouches, leggings, and the binding of books likely to be subjected to rough wear.

Glove leather: Pigskin is used both for work and for dress gloves.

Other leathers: Pigskin leather was formerly preferred for the covering of footballs. Now, however, cattle hides are better fitted for the purpose, and the output of genuine pigskin football leather is very small. The only other purpose for which pigskins are used in appreciable quantities is for the manufacture of leather leggings or gaiters.

SECONDARY USES OF LEATHER.—The services of leather do not end with the primary uses. Each of the industries built up on the utilization of packing-house by-products has its own wastes, and a certain amount of waste is incurred in tanning hides. Very little of this waste, however, is not converted into a useful product. For example, spent tan bark is sold as fertilizer, and also is used to a certain extent in paper making. Leather trimmings and scrap are pressed and rolled into sheets, with some glutinous composition, to form artificial leather; or they are utilized in the production of printing inks, dark pigments, covering substances, and blacking. Hundreds of patents have been granted for various methods of working over bits of leather which the ordinary man would sweep away. Minced with the bones of sheep and goats, leather scrap is transformed by one inventor into ivory veneers. A process has been patented of pressing leather shavings into boot and shoe heels and inner soles. What is called "shoddy" leather is made by grinding bits of waste leather to a pulp, which, after maceration and pressure, is formed into solid strips. Leather that no one else can employ is left for the glue maker.

Recently, still further uses have been found for waste leather scraps produced in shoe factories and tanneries. In one process for treating this leather, the first step is to pack the scraps into a barrel-like container which is heated externally. This process is similar to that by which illuminating gas is made. A black mass remains in the retort, and a liquid is extracted from the expelled matter. Thus the scrap is decomposed simply by heat into a solid, a liquid, and a gas. The inventor of this process claims many valuable commercial products as the results of his discovery. For example, the black residue is animal charcoal and can be used in filtering and decolorizing certain leather. Upper leather yields a charcoal that gives a valuable green pigment known as chrome

oxide green. A gas resulting from this process can be used for heating. The other main product is a liquid consisting of two layers, a watery and an oily one. The watery layer contains ammonia easily recoverable as sal ammoniac. This contains also some pyrocatechol and pyrogallol, which are photographic developers. The oil contains a whole family of chemical compounds called "pyrrols," some of which can be made into antiseptics and are very valuable. These pyrrols are convertible into compounds known as pyrrolidins, some of which can be used as sprays to kill pests on plants.

A readily observable trend toward leather substitutes began before the World War, due to high prices of leather. But the ultimate success of these substitute products, most of which are new, is not yet assured. Because hides and skins are by-products, it follows that as long as hide- and skin-bearing animals are raised, and as long as there is a demand for their primary products, so long will leather raw stock be produced. A wave of leather substitute competition might cause demand for some classes of hides and skins to decrease temporarily. But the supply would not contract, and raw stock prices would soon fall so low that the competitive advantage would bring about a state of equilibrium. Still, two conclusions regarding substitutes may be noted: (1) For some purposes, e.g., rubber heels, the substitute has proved to be a superior commercial article to leather, and will be be permanently used, so that the leather formerly utilized for that purpose must be diverted elsewhere. (2) In other cases, the substitute will displace leather only where the difference in price must be considered. For example, heavy leather soles for street wear are still superior to rubber or composition soles, and the latter is used only for purposes of economy, although a small percentage of rubber-soled shoes may be worn for waterproof and sport. Similar considerations govern the competition between leather and fabricated belting.

Marketing of Leather

Leather has a considerable number of market outlets. Sole leather leaves the tanner in the shape of sides and may be sold

to the shoe manufacturer, who will use every part of it in the making of his shoes; or it may be sold as a back, which is a side with its head, shanks, and belly removed; or again as a bend, with the head, shoulder, shanks, and belly removed. The leather may be cut to small dimensions by the tanners and sold as strips or blocks, a strip being about $8\frac{1}{4}$ inches wide by $2–2\frac{1}{2}$ feet long, and a block about $12\frac{1}{2}\times 8\frac{1}{4}$ inches. Leather in the form of strips and blocks is used mostly by repairmen or sold through hardware and general stores to those who repair their own shoes. The tanner, in many instances, will sell his leather as backs and sides to the sole cutter, who in turn will sell to the shoe manufacturer in the shape of outsoles, insoles, counters, heels, box toes, etc., uniformly graded for quality and thickness. In general, sole, harness, and belting leather find the following outlets: shoe manufacturers, belting manufacturers, harness manufacturers, sole cutters, jobbers (less and less), and finders (who buy in large quantities for the repair trade and peddle to cobblers).

The outlets for sheepskins include shoe manufacturers, novelty and pocketbook manufacturers, bookbinders, shoe finders, glove manufacturers, jobbers, cotton mills, gas manufacturers, garment manufacturers (for coats, vests, etc.), harness and saddlery manufacturers.

The characteristic trend in the marketing of leather today is toward a quicker turnover. In common with the trend of general business, smaller stocks and more frequent orders are the rule. The activating causes stimulating this change were the business deflation following the World War, the later increase in purchasing power of the consumer, and the more rapid changes in style which have accelerated the rate of consumption. As a result, the risks of the business have been pushed closer to the producer of the raw materials. The retailer is drawing only limited stocks from the distributor; the distributor is demanding complete shifts in the patterns and products of the manufacturer; the manufacturer is buying leather from the tanner to fill orders only as he receives them; the tanner draws on the slaughterer only on a hand-to-mouth basis. This produced a condition of stagnation

for the packer and livestock producer in 1920, 1921, and 1922, but today, when war stocks have been worked off, it results in a rather constant weekly flow of trade into consumptive channels.

The international trade in hides and skins, partly on account of the fluctuations mentioned, has increased with the steady and decided improvement in the demand for leather since the war, which has, in turn, caused a larger international demand for the raw materials, hides and skins. Estimates of the Hide and Leather Division of the United States Bureau of Foreign and Domestic Commerce place the annual trade in hides and skins at almost double the yearly trade prior to the war. Not only has the volume of this trade increased, but in some instances international trends have also shown considerable change, and at present hides and skins form one of the most important raw materials entering into world-trade.

CHAPTER III

WOOL AND HAIR

Wool, the oldest of the textiles, is like hides and skins, a by-product of the meat industry. Of the total American wool production, however, only about 15 per cent, viz., the pulled wool, can be considered a by-product of the packing business. Most of our wool production is from the wool shorn before the sheep themselves are sold to meat packers for slaughter. Nevertheless, the production of pulled wool amounting to some 50,000,000 pounds a year constitutes an important by-product and is a prime raw material for the textile manufacturing industry. In this discussion of wool as a by-product of meat packing, a seemingly lengthy general description of wool is given prior to a consideration of pulled wool itself. The justification of this method of presentation is that in spite of its fundamental importance, the public knows less about wool and quality in woolen goods than about silk, cotton, or linen. Wool is the one textile for which no satisfactory substitute has yet been found. There is rayon for silk, and materials are made from various fibers that serve as substitutes for cotton and linen, but no textile has been successfully developed to take the place of wool.

In 1926 the total United States wool production was as follows: Shorn wool, 269,054,000 lb.; pulled wool, 50,000,000 lb.; total, 319,054,000 lb. The total pulled wool produced may be divided into the following qualities: Fine and fine medium, and medium and coarse. Comparing the present production of shorn and pulled wool in the United States with other years, an estimate has been made from the period 1910–26 by the U.S. Department of Agriculture as shown in Table V.

Considering total wool production for the past three decades, it can be stated that, in general, there have been periods ever since 1895 in which the world has tended to consume more wool

annually than it currently produced. During the past thirty years experience has shown: (1) That around a certain price the production and consumption of wool have been very nearly balanced. This price was not always the same price, and it varies according to the barometer of general prosperity and the composite prices of various other staple commodities. (2) That when

TABLE V

UNITED STATES PULLED AND SHORN WOOL PRODUCTION, 1910–26

Year	Pulled Wool (Pounds)	Shorn Wool (Pounds)	Total Production (Pounds)	Percentage of Pulled Wool in Total Production
1926	50,000,000	269,054,000	319,054,000	15.6
1925	46,800,000	254,260,000	301,060,000	15.5
1924	43,800,000	238,530,000	282,330,000	15.5
1923	42,500,000	224,330,000	266,830,000	15.9
1922	42,000,000	222,560,000	264,560,000	15.8
1921	48,500,000	223,062,000	271,562,000	17.9
1920	42,900,000	235,005,000	277,905,000	15.4
1919	48,300,000	249,958,000	298,258,000	16.1
1918	42,000,000	256,870,000	298,870,000	14.1
1917	40,000,000	241,892,000	281,892,000	14.2
1916	43,600,000	244,890,000	288,490,000	15.1
1915	40,000,000	245,726,000	285,726,000	14.0
1914	43,000,000	247,192,000	290,192,000	14.8
1913	43,500,000	252,675,000	296,175,000	14.7
1912	41,500,000	262,543,000	304,043,000	13.6
1911	41,000,000	277,548,000	318,548,000	12.9
1910	40,000,000	281,363,000	321,363,000	12.4

wool prices are low compared to the general level, and below or in line with the prices of various other staple commodities, the world will absorb a great deal more wool than it is currently producing. (3) That after a period of comparatively low prices the surplus of wool accumulated during a preceding period of high prices will have been absorbed, and wool prices, relieved of the pressure of a wool surplus, will begin to rise again. (4) That abnormally high prices for wool, that is, prices not justified by the general current level of prices gradually, sometimes suddenly, shut off buying by the distributing trades.[1]

[1] Albert W. Elliott, "The Wool Outlook," *National Wool Grower*, Vol. XVII, No. 2 (Feb., 1927). Address before the National Wool Growers Association, January 30, 1927.

Trends in Wool Consumption

At the present time, in spite of a visible tendency to increase the production of all wools, such increase of production is not likely to outstrip the growth in the wool-using population of the world, for the latter is growing somewhat more rapidly than any possible increase that can develop in wool production. The future trend in wool consumption will be affected by two elements in the price

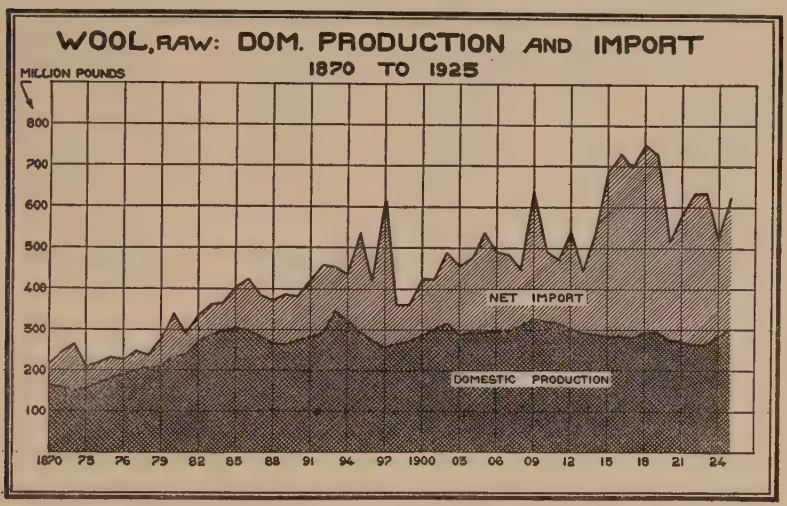


Fig. 7

situation. The first of these factors is the relation between wool prices and the prices of other commodities. Consumers of articles made from wool, both pulled and shorn, are those who produce other agricultural commodities, or who are employed in industry. Such consumers cannot afford to use wool to the same extent if its price is above the price they receive for their commodities. The second factor is the wage which consumers on farms, in factories, banks, stores, railroads, ships, building, domestic service, and professions receive for their services. In the United States consumers have bettered their economic position to such an extent that the production of both pulled and shorn wool can be increased with assurance of greater consumption. An article of

prime necessity, wool will continue to hold an important place in national consumption of raw materials for clothing and covering.

The past trend in pulled-wool consumption, both foreign and domestic, in the United States since 1918 according to the National Association of Wool Manufacturers is shown in Tables VI and VII.

World Production of Pulled Wool

TABLE VI

	Pounds		Pounds
1926		1922	
Domestic	15,730,316	Domestic	19,450,000
Foreign	16,044,596	Foreign	8,124,000
Total	31,774,912	Total	27,574,000
1925		1921	
Domestic	15,238,000	Domestic	20,469,000
Foreign	11,614,000	Foreign	6,006,000
Total	26,852,000	Total	26,475,000
1924		1920	
Domestic	15,359,000	Domestic	13,660,000
Foreign	7,691,000	Foreign	4,316,000
Total	23,050,000	Total	17,976,000
1923		1919	
Domestic	16,368,000	Domestic	18,592,000
Foreign	12,298,000	Foreign	4,776,000
Total	28,666,000	Total	23,368,000

1918	
Domestic	18,552,000
Foreign	7,179,000
Total	23,731,000

TABLE VII*

WORLD WOOL PRODUCTION FOR FIVE-YEAR AVERAGE, 1909–13, AND YEARS 1925 AND 1926

(IN THOUSANDS OF POUNDS)

Countries	1909–13 (Average)	1925	1926
Commercially important producers:			
United States	314,110	292,362	310,901
Argentina	358,688	312,400	314,840
Chile	17,430	33,000	31,000
Uruguay	156,968	117,000	125,000
Bulgaria	23,700	29,769	25,450
France	80,688	44,974	47,619
Germany	52,000	50,160	41,710
Italy	55,000	57,000	55,800
Spain	72,000	88,469	105,792
United Kingdom	134,000	96,132	99,600
Jugoslavia	25,446	28,000	28,727
Algeria	35,221	46,137	38,649
British South Africa	165,888	185,000	180,000
Australia and Tasmania	705,146	732,807	768,000
New Zealand	198,474	199,731	207,801
All other countries	181,248	240,590	252,891
Total	2,576,007	2,553,531	2,633,780
Other producers:			
Russia (European and Asiatic)	380,000	195,000	195,000
British India	60,000	60,000	55,000
China	50,000	75,000	75,000
Turkey (European and Asiatic)	118,000	12,500	13,000
All other	64,470	86,530	88,950
Total	672,470	429,030	426,950
Grand total world wool production	3,248,477	2,982,561	3,060,730

* According to revised data of the United States Department of Commerce.

THE NATURE OF WOOL

Successful handling of pulled wool in the packing industry requires a knowledge of the chemical nature of wool. It is a product composed of several complex protein compounds, of which keratin is the principal one, as it is in the case of skin, hair, and hoofs. Due to its chemical composition, wool is able to resist the action of most acids, although it dissolves readily in a strong alkali. An expert in woolen fabrics can detect the proportion of wool in a cotton mixed fabric by immersing the fabric in a solution of caustic soda,

which dissolves the wool but leaves the cotton fabric. In common with all kinds of hair, wool is a growth originating in the skin. It is similar to various other skin tissues, such as hair, nails, hoofs, horns, and feathers. Each wool fiber grows from the bottom of a pocket-like depression in the skin called a follicle. The wool fiber itself is of a tubular nature and consists of three layers, as follows: (1) The medulla, a cellular marrow which partially or completely fills the central cavity of the fiber. This absorbs water when the wool is moistened. (2) The cortex. This is the main wall of the fiber surrounding the medulla, and is composed of many elongated conical cells. It is the portion of the fiber which furnishes most of the strength and elasticity. (3) The epidermis. This is the outside or surface of the fiber, and consists of flattened cells or scales, the ends of which generally overlap each other and project outward, causing the edge of the fiber to present a serrated appearance. This scaly covering gives the fiber its quality of rigidity and resistance and produces the so-called "felting" property of wool through the interlocking of the projecting edges of the scales. In merino wool the fibers are so fine that each scale reaches all around its surface. The free edges of the scales in fine wool are more protruding than in medium or long wool.

In the preparation of both pulled and shorn wool for manufacture into textiles there are certain essential requirements to be met by the producer, whether packer or sheep raiser, as follows:

1. The *fineness* of wool should be sufficient to spin to the required counts or numbers of worsted or woolen yarn, and to make a strong, smooth, and elastic yarn, which will stand up during warping and wearing.

2. Its *strength* must be great enough to withstand the strains imposed on the fiber in the various operations of yarn manufacture, in order not to make an excessive amount of noils and waste.

3. The staple *length* should be such that the desired finish on the fabric is possible.

4. The wool should be pliable and possess the proper degree of *softness* or *hardness*, to give the desired "feel" and "handle" to the finished fabric.

5. It should have the *felting properties*, which will permit the fabric to be fulled in finishing so as to furnish the desired shrinkage, appearance, and "handle" in the finished goods.

6. If a white *color* is desired for certain fabrics, or a blending with colors to form mixtures, the wool must scour out a clean white.

Wool Classifications

Both pulled and shorn wool must be classified and graded before they can enter into regular commercial channels. While pulled-wool producers apparently deal with but one class of wool, they must meet with the general classifications throughout the world. Accurate classification of wool is important, but very difficult, for its qualities vary, not only with the different breeds of sheep, but with their health and such conditions as variations in soil and climate. Again, wools are graded on the basis of their length, fineness, and general characteristics, which include fineness, or diameter of fiber, length of fiber, strength, elasticity, softness and pliability, color, luster, felting, shrinking, and working qualities. In the United States there is a great variety of wool classifications, but none is accurate or comprehensive. At present the United States Department of Agriculture is striving to arrive at a standard classification, and has conducted a world-wide survey, in co-operation with producers and manufacturers, upon which to base it.

One classification is a geographic one. Wools from the region east of the Missouri River are called domestic or "fleece" wools, and wools west of the Missouri are known as territory wools. These two divisions may be further subdivided. For example, some territory wools are classed as fine staple, fine medium staple, or fine medium clothing. In the case of Texas wools they are divided into fine fall medium, medium fall, twelve-months, and eight-months. On the other hand, California wools are classed as spring, northern, and fall. Of the two general classes, i.e., domestic and territory, domestic wools are cleaner and do not show as great shrinkage in scouring. This is due to the fact that domestic wools come from farm flocks which receive better care

and shelter. Shrinkage in wools from well-cared-for eastern flocks is from 50 to 60 per cent in scouring, but fine territory wools shrink as much as 65 to 75 per cent.

A rough classification, generally adopted for convenience, divides all wools into *combing*, *clothing*, and *carpet* wools. This classification is based on the length of the fiber, with the dividing point varying from $2\frac{1}{2}$ inches for the fine wools to 4 inches in the coarsest grades. It is based on the different uses to which the long and short wools are put. The longer selections are combed, after the English or Bradford system, and the fibers are twisted during the spinning of the yarn. Length and strength are the essential qualities for this process in the wool. The shorter wools, however, cannot be properly twisted, and therefore they are carded and the fibers are thoroughly mixed so that they point in all directions. The spinning machine subsequently draws the yarn.

From the long combing wools are made worsted yarns, and the clothes made from them are called worsteds. The clothes made from carded wool, on the other hand, are called woolens, and have a soft, downy texture, while worsteds are hard and smooth, showing the yarn distinctly. By a special, so-called "French" system, shorter wools than those handled according to the English system may be spun to a yarn of worsted type, although this yarn has several of the characteristics of the woolens.

Within the classes of combing or clothing wools, either of domestic or territorial origin, a number of grades are established, based on the fineness of the fibers. The common grades are: fine, fine medium, half blood, three-eighths blood, one-quarter blood, low quarter, braid, and common. There are other specific terms used, and frequently further subdivisions are made, but the grades just listed are representative. The names of these grades were established many years ago and were supposed to indicate the degree of Merino blood in the sheep. They have, however, no relation to present-day breeding.

Most of the commercial wool of this country falls in the following main groups: (1) Merino wool (including Rambouillet); (2) wool from British breeds of sheep, falling again in two subgroups,

the medium wools derived from the Down breeds, and the long wools from the Cotswold, Leicester, Lincoln, and Romney Marsh; (3) wool from crosses between Merino and Down breeds, or the long-wool breeds, respectively; (4) carpet wools. Fine wools are produced by sheep carrying a predominance of Merino blood, although the coarser Rambouillets may grade medium. The very finest selections of Merino wool are produced in but small quantities in this country. Such fine wools are superior because of the thickness of the fleece, the extremely fine crimp, the prominence of the microscopic scales, and the uniform fineness and density of the fibers. Most of the Down breeds produce wool grading from medium for the very finest to low quarter for the coarse Oxford Downs. These wools appear more "lofty" because of the fact that the fibers stand farther apart in the skin. The long-wool breeds grade as "common" if lacking in luster, otherwise as "braid." Of the ordinary crosses found on the western sheep ranges, the half-blood Cotswold-Rambouillet produces mostly three-eighths-blood wool; one-quarter Cotswold–three-quarter Rambouillet produces mostly half-blood; and three-quarter Cotswold–one-quarter Rambouillet produces quarter-blood or low-quarter wools.

Outside of the United States, other units of grading are used. The most common of these is the English system, based on spinning counts. These grades can be compared as follows:

British	American
80's, 70's, 64's	Fine
60's, 58's	Half-blood
56's	Three-eighths blood
50's, 48's	Quarter-blood
46's	Low-quarter blood
44's	Common
40's	Braid
36's	———

Finally, all wools may be classified as either shorn wools or pulled wools. And this is the classification of most interest to the packing industry. For pulled wool is the wool with which the packer is concerned as a by-product of his business.

All wools sheared from sheep are known as fleece wools. Most of them are sheared from the full-grown sheep at a regular season, once a year, but a certain proportion, i.e., Texas and California sheep, are shorn in both spring and fall and their fleeces are classified as spring and fall wools. Fleece weights vary according to a number of factors. In trade estimates use is made of average weights. The average weight for a fleece is obtained by dividing the total weight of fleece wool by the number of fleeces. Through methods employed by the United States Bureau of Agricultural Economics and the National Association of Wool Manufacturers, the average weight is directly ascertained by states, and the United States average is a weighted one. From 1840 to the present time fleece weight has increased in the United States some 3.8 times, which indicates great efforts to improve breeds of sheep and to acquire those that produce more and finer wool. The average fleece weight of 1840 was only 1.85 lb.; by 1850 it was 2.42 lb., and by 1866 the average was 3.24 lb. When 1880 arrived the average was 4.80 lb., and the estimate for 1884 was 5.20 lb.; for 1893, 6.38 lb.; and in 1900 it was 6.29. In 1909 it was 6.84 lb.; in 1911 it was nearly 7 lb., and in 1917 it reached 7 lb. Wool apparently reached its highest production in the United States in 1909, since which time there has been a decline in relation to population. By 1917 the United States per capita wool production was a scant 60 per cent of the average for the decade 1875–84.

Sorting and Handling Wools

In the operation of sorting fleece wools into grades, the fleece is usually spread out on a table, the center of which is covered with wire netting. Working inward from the edges of the fleece, a sorter tears out different parts with his hands and places them in separate piles according to the different qualities. The fleece is banged and shaken on the table so that a good deal of the dust

WASHING SHEEP PELTS

PAINTING FLESH SIDE OF SHEEP PELT TO LOOSEN WOOL ROOTS

and loose dirt in it falls through the wire netting. The sorter then removes from the fleece with his hands all lumps of dirt, matted fibers, large burrs, and other roughage.

All wools contain, in addition to dust, burrs, and fodder, a considerable amount of "suint" or yolk, usually known as grease. The latter is partly perspiration and partly a fatty exudation from the sheep's body, which seems to serve the purpose of protecting the wool on the sheep's back from injury by the weather. Another foreign substance in wool, difficult to remove and causing trouble and loss in certain types of the textile industry, is the paint used in branding sheep running on open ranges, to indicate ownership. The wool trade has tried to improve this condition, unfortunately with no great success. The trouble has been due to the fact that sheep raisers use a ready mixed paint, adding some cheap pigment to give a red or black color, e.g., red oxide or lamp black; and this color clings to the wool, hardens when exposed to the air, and can be removed only by clipping. Indeed, it is practically impossible to remove all the paint from the fleece, whether handling it as shorn or pulled wool. Therefore, when the wool reaches the mills the effect on fabric for underwear or lengths of white flannel is most objectionable. The presence of this "paint" depreciates the value of the wool, and buyers discriminate against it. However, ranchmen still use this paint since it seems more desirable to them to lose a few cents on a fleece than to lose a whole sheep.

All grease and dirt must be removed before the wool can be worked properly. This is done, as a rule, by scouring the wool in warm water, soap, and a mild alkali, such as ammonium carbonate or some similar substance. In the process of scouring, the wool passes through three or four vats filled with the scouring liquid. Each vat is equipped with automatic rakes which stir the wool in the liquid, and with a set of rollers which squeeze the liquid from the wool. All vegetable matter is not removed in this process, and such material, including burrs, detracts from the value of the wool, since an additional process, viz., carbonizing, is necessary to remove this foreign vegetable matter. This carbonizing con-

sists of a dilute sulphuric acid bath, and costs twice as much as the ordinary scouring operation. Following this the wool is dried artificially and packed in bales of 100–500 lb. each.

As the wool from different parts of a sheep varies in quality, each fleece contains a number of qualities. The most valuable wool is from the shoulders and sides of the sheep. Next in value is that from the lower part of the back, the loins and back, and the upper part of the legs. Wool from the neck, breech, belly, chest, head, throat, and lower part of the legs is all inferior.

Methods of Pulling Wool

Pulled wool is the wool produced from packing operations, for today the supply of pulled wool is usually obtained in the wool houses of packing plants. In the United States the most important packers' pulling establishments are in Chicago, New York City, St. Joseph, and Kansas City. There are about forty pulling establishments in this country, and some 25 per cent of the total volume of pulled wool is produced in the east. While usually called pulled wool, it is also known by the following trade names: skin wool, tanners' wool, slipe wool, and butchers' wool.

After sheep are killed in a packing plant, the pelts are pulled from the carcass and are taken to the wool house. At this point the pelt is prepared for dewooling and the skin for tanning. The resulting wool is two or three times as valuable as the skin. Generally, before the skin is tanned, it is necessary to remove all the wool. The only exception to this is when the pelt is to be used for sheepskin coats, robes, and rugs. The three principal methods of pulling wool are: (1) the sweating process, (2) the lime process, and (3) the depilatory process. Of these, the first two are very little used in the United States. In the sweating process the wool skins are hung on racks in a warm room with the atmosphere artificially moistened. The heat and moisture initiate bacterial action which loosens the roots of the wool, so that it can easily be pulled out by handfuls. Great care must be taken when using this process, as the skins rot and decompose if they are left hanging too long. This process is employed only on inferior skins.

In the lime process the wool skins coming from the killing floor are thrown into tanks of water and allowed to soak overnight in order to remove grease, dirt, and other foreign matter from the wool. The pelts are taken from the water tanks to scrubbing machines, which further cleanse the fleece. This process is better known as brushing, which practically all pulled wools undergo. The scrubbing machine has a revolving steel cylinder placed over a lattice feeding apron. The cylinder has a spiral knife or edge with about a 2-inch pitch covering its entire working surface, similar to a screw thread. In front of the cylinder is a perforated water pipe, which operates under 90 pounds of pressure and throws the cold water on the fleece side of the pelt as the apron carries it to the cylinder. The working edges of the cylinder are blunt, and do not cut the wool, but, by giving a scrubbing action, are very effective in removing burrs.

The pelts are then ready for painting, which is the most important operation in the process. The skins are turned with the flesh side up and are carefully painted with slaked lime, which opens the skin pores and loosens the wool roots. The lime remains on the skins overnight, when it is cleaned off and the skins are taken to the pulling room. The lime process succeeded the sweating process and was the method employed in the United States until recently, when it was superseded by the depilatory process. Pulled wool obtained by the lime process is also known as "slipe" wool.

The depilatory process involves the same steps as the one described, except that in the painting room, sodium sulphide, sulphuric acid, and ground oyster shells form the compound applied to the flesh side of the skins, after which it is allowed to stand about ten hours. This is the most satisfactory process, and it is the one usually employed in the United States because it causes the least damage to both wool and skin.

Grading and Sorting Pulled Wool

When sheep pelts reach the pulling room they are first graded according to the fineness and length of the wool. Since all kinds

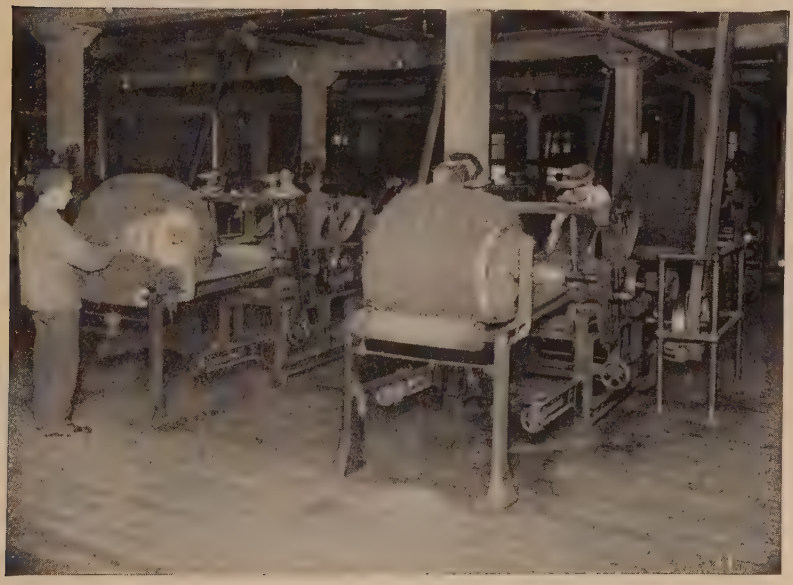
and breeds of sheep are slaughtered, the pelts carry a very wide range of wools, and therefore careful grading and sorting are necessary. In pulled wools the length of the fiber is governed principally by the length of time which has elapsed between shearing and slaughtering. For example, the wools from the Merino breeds are classed as clothing, while the wools from the medium- and long-wool breeds are long enough to be classed as combing wool after six months' growth. Practically all the wools pulled from June to October, inclusive, are carding wools.

After being graded, the pelts are ready for pulling and sorting. A man throws the pelt on a specially designed bench, fleece side up, and quickly pulls the wool from the skin by the handful, throwing it into one of several barrels conveniently placed to receive the different grades of wool from the various parts of the pelts. When the receptacles are filled, the wool is dried and taken to the store room, where it is dumped into bins. Each individual fleece thus loses its identity.

Under one simple method of grading pulled wool only four grades are used, viz., *AA*, *A*, *B*, *C*. *AA* represents the two best grades in the domestic and territory wools. *A* equals half blood domestic and medium territory. *B* corresponds to three-eighths blood and one-quarter blood in both domestic and territory fleeces. *C* covers both common and braid in these classifications. While some smaller packers make but a half-dozen grades, the larger packers make about fifty grades. Because of this grading there results one of the chief advantages of pulled wool, viz., that, due to its very careful sorting, it is suitable for the manufacturer-user to put into his machine without any further grading and selection. The puller makes many times more grades or sorts than any handler of shorn wool.

Another system of grading pulled wool uses only three grades, viz., fine, medium, and coarse. Under this classification fine would correspond to one-half blood and above, medium would cover three-eighths and one-fourth blood, and coarse would represent common and braid. The puller usually makes very few sorts from one skin. A fine fleece would be divided into *AA* and *A*, and the

PULLING WOOL FROM PELTS



DRYING AND FLUFFING CURLED HAIR

low parts would be thrown into *B*. A medium fleece would be given two sorts, *B* and *C*, while a coarse fleece would be thrown entirely into *C*. Each grade must also be sorted for clothing and combing wools.

The very short wool obtained from sheep sheared less than one month before slaughtering averages up to 1 inch in length, and is known as "shearling." The shearling skins, for the most part, are not pulled, but are tanned with the wool on for the lining of slippers and sheepskin coats. This wool is also used in the manufacture of hats and felts.

The average shrinkage of pulled wool is 27–30 per cent, compared to 40–60 per cent for shorn wool. All pulled wools are washed in process, and the shrinkage which the dealer and manufacturer have to consider is based upon the wool in the washed state and not upon the original condition in the fleece. The approximate shrinkages for American pulled wools are estimated as follows: *AA*, 35–38 per cent; *A*, 20–25 per cent; *B*, 15–20 per cent; and *C*, 13–18 per cent.

Uses of Pulled Wools

Pulled wools can be used for any purpose to which others may be put. Indeed, in making many articles they are preferred, because the pullers furnish carefully graded stocks, exactly suited for a manufacturer's especial use. Pulled wools are used in medium and coarse fabrics, and large quantities are consumed by woolen mills featuring all-wool products. They are also used in blends with wool substitutes and with cotton for making Merino yarn. Pulled wools are especially adapted for soft-twist knitting yarns. Blanket mills employ large quantities of the finer grades of pulled wools, because due to their length, they make a more attractive bed blanket than sheared wools. Blanket mills also use a great deal of medium or *B* grade of pulled wools, because of their even grade and cleanness, their equal being seldom obtained from shorn wool. On the other hand, yarns made with pulled wool are more open than those made by fleece wools, because the pulled wool fibers do not cling as closely in drafting and twisting. When man-

ufactured it is very difficult to distinguish between pulled wool and sheared wool. In brief, pulled wool is largely used in the manufacture of soft-twist knitting yarns, bed blankets, carpets and rugs, woven paper, and mill felts, cheviots, cassimeres, flannels, and dress goods.

Wool Marketing Methods

In general, wool is marketed in the United States by private treaty, while the auction system is used in most of the world outside this country. The reasons why the auction system is not used in America are: (1) A wide variation exists in American wools. (2) The business habits of Americans are based on an inherent instinct to trade as individuals. (3) Sheep raising is not standardized in this country. (4) Breeders shift their favor from one breed to another. (5) Grading is not performed at the shearing shed.

The greatest wool market, both for pulled and fleece wool, in the United States is Boston, due to its early establishment and its proximity to the wool manufacturing centers. But Chicago, New York, and Philadelphia are also growing annually in relative importance. Fleece wool sales are transacted through brokers and commission men, who deal directly with textile mills. The producer may sell his fleeces to country buyers who come directly to farm or ranch, or he may deliver them to local assemblers, private or co-operative, who in turn sell them to dealers, commission merchants, brokers, or direct to the manufacturer. The producer may also consign his commodity to wool warehouse companies, privately or co-operatively owned, under which system he gets an advance on the wool at time of delivery, but final settlement only when it is sold. The wool warehouses, or assemblers, grade the wool and sell it to brokers or mills. In the range states, however, different methods are in vogue. Sometimes wool is sold by contract even before it is shorn, and frequently eastern buyers deal directly with the wool growers of limited areas, presenting sealed bids to the individual grower or the co-operative association on a competitive basis.

In recent years co-operative wool pools have been organized

with the purpose of disposing of the range wool in a more profitable way. These pools sort and grade the product and sell it to dealers, or direct to the mills. The producer receives the selling price minus certain charges for handling the wool. Since 1919 the number of co-operative wool pools has doubled. About 75 per cent of the wool sold co-operatively is now handled by country, regional, or state organizations. The chief significant features of the recent marketing of territory wools are the enlargement and extension of the warehousing and marketing of wool on the Pacific coast, and a tendency against consignments to eastern concerns. In the future it is probable that, even under ordinary circumstances, the handling and selling of wool will be done in increasing volume nearer to the areas of production.

As in the case of the livestock and meat industry itself, the concentrated areas of wool production and consumption have become widely separated because of the development of intermediary agents who have assumed the risks of handling the product en route to the consumer, and who have developed efficient methods of transporting, grading, and processing. The number of these middlemen varies in different localities, at different times, and with changing market and economic conditions. For example, fleece wools are usually handled by a greater number of middlemen than western wools, because western wools are produced and marketed in larger lots than fleece wools.

The principal wool-marketing agencies are: local wool dealer, local pool or co-operative wool-growers' association; state dealer or state co-operative wool-growers' association, central market dealer, commission merchant, broker, and manufacturer. However, no one lot of wool is ever handled by all these intermediary agencies. The more important functions of these principal market agencies may be described briefly as follows: The local dealer is usually a local merchant who devotes part of his time to buying the small clips of wool in his vicinity. After buying small lots of wool, he assembles them into larger lots and resells to a larger dealer. The local pool is an association of local growers formed for the purpose of assembling wool in sufficient quantities to attract rep-

sentatives of the larger central market. The wool assembled may or may not be graded, but usually it is not. A local pool may sell to a state dealer, a central market dealer, a commission merchant, a broker, or a manufacturer's representative.

A state or regional co-operative wool-growers' association is similar to a local pool, except that it is usually more highly organized and handles larger quantities of wool. Therefore, a state or regional pool is more likely to attract manufacturer buyers. A state dealer performs the same functions as a state or regional co-operative wool growers' association in collecting wool from a state or region, but buys and sells for himself.

A central market dealer assembles wool in large quantities from a variety of sources and representing a wide variety of classes and grades. His agents are in the most important wool-producing areas of the world, and at points of concentration where wool is sold either at auction or by private treaty. His chief function is that of assembling wool at a point where it can be inspected by the manufacturer, and of grading in such a way as to meet the manufacturers' needs. The central market dealer may buy direct from the producer or from anyone who assembles wool. As a rule he sells to the manufacturer, but he may sell to a broker or another central market dealer. In fact, the dealer is the largest factor in wool distribution, for he furnishes service in financing, storing, and grading, and in sending his salesmen with samples to call upon the mills. He has his buyers in the western country to buy the wool, and pays net cost. The dealer buys usually within a three months' period but he sells this wool to the mills for delivery to them, in the quantity and quality they require, over a twelve months' period. The normal procedure in selling wool to manufacturers is for the dealer to give the latter credit for sixty days from date of sale. It is this financial service which is the fundamental reason for the wool dealer's existence, for most mills cannot afford the expense of sending buyers West and of storing and financing a year's supply of wool.

The commission merchant performs the same functions as the

central market dealer. However, he does not buy and sell for himself, but accepts wool for his clients, and stores, grades, and sells it, charging a commission for his services. He usually sells to a manufacturer, although he may sell to a broker who stands nearest the manufacturer in the chain of marketing agencies. Yet he is a very small factor in the organization of the wool trade as it exists in the United States. He acts as the immediate representative of the manufacturer. His chief function is to assist the manufacturer in locating and getting exactly the kind and grade of wool he wants. He may buy from any source and sell to any other, but he usually sells to the manufacturer, who is considered the consumer of the raw wool, for he takes the wool as it has been graded, sorts each fleece into various qualities, and manufactures it into articles of commerce.

In general, then, the methods of marketing wool in the United States may be summarized as follows: (1) through the local dealer, (2) direct to local mills, (3) direct to central market dealers, (4) by consignment to commission merchants, (5) through local wool pools, (6) through state or regional co-operative wool-growers' associations, (7) direct to the wool manufacturer.

Sheep and lambs are slaughtered at all of the principal public livestock markets. Particularly in Chicago, meat packers have developed facilities for processing and distributing the mutton and lamb, and also the pulled wool as a by-product. Some of the larger packing companies sell this wool under their own name, while others sell it through subsidiary companies. In this trade the wool merchant is not a contributing factor, since most mills buy pulled wool direct. The pulling houses scour large quantities of wool, usually compressing it into bales resembling small cotton bales. Over half the pulled wool of this country is marketed in a scoured condition. But the combing wools are always sold in the grease, more effectiveness in shrinkage being much less than in the fleece wools, due to the soaking in water and the brushing process. The price therefore usually ranges 10–20 per cent above the similar fleece wool, depending on the market.

Wool Prices

Pulled-wool, as well as fleece-wool, prices are influenced by the same basic economic factors. But pulled wools have their own trade circumstances affecting short-time price variations, and the same is true of fleece wools. Unfortunately, there is no very widely accepted standard, national or international, of either kind of

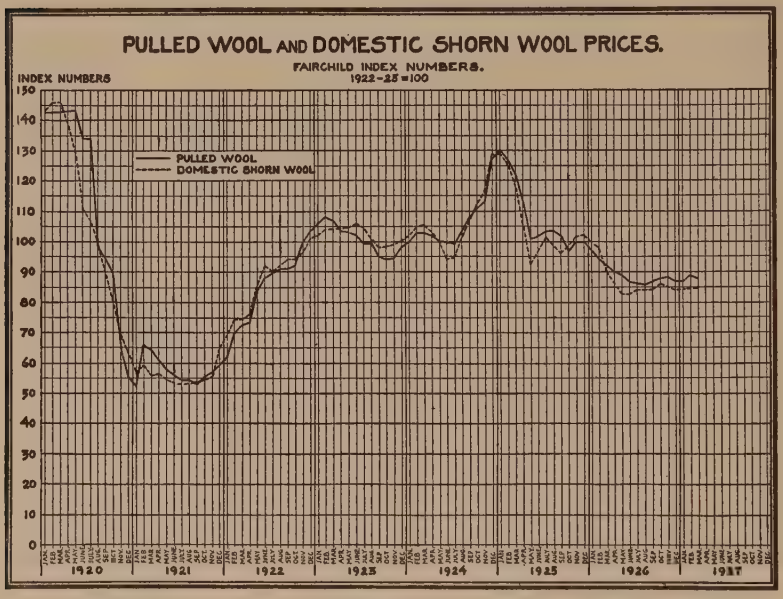


Fig. 8

wool which can be used for a price comparison covering a long period. But there is a definite relationship between prices of pulled wool and fleece wool, as is indicated in the accompanying chart showing the indexes of the average price of domestic wool and the average price of pulled wool. However, a general survey of wool-price factors and fluctuations is necessary in giving a complete picture of the position of pulled wool and its problems as a by-product business of the packing industry.

There has been much misconception concerning the trends and causes of wool prices during the last fifteen years, and mis-

understanding of the factors which have chiefly influenced the consumer costs of clothing made wholly or in part of wool.[1] At the beginning of the war there was a general belief that the great quantities of wool required for military use would cause a serious shortage of the staple, if not an actual wool famine. As a result, during the war, wool prices rose, in common with other commodities, but the rise in prices for wool was much greater, and the purchasing power of wool amounted to slightly over 180 per cent of the pre-war level. However, some other influences upon the supply were entirely overlooked. The increased consumption by the Allied Countries for military purposes was largely offset by the decreased demand for civilian use, and by the inability of the mills of Germany, Austria, and Poland to obtain supplies. Besides these counteracting influences, there developed a great restriction of transportation by sea, due to the enormous destruction of merchant shipping by the submarine warfare, and to the need of much of the available tonnage for the transportation of troops, munitions, and supplies for the armies. Therefore, instead of the expected deficiency of wool at the end of the war, there was a huge surplus in the principal countries from which it was normally exported, viz., Australia, New Zealand, and South America, due to the war-time shipping shortage. For a little more than a year after the armistice, the deficiency of sea transport and the employment of many vessels in the return of troops delayed the movement of wool from these primary markets, so that notwithstanding the great surplus in Australia, South America, and South Africa, there was a temporary lack of needed varieties in Great Britain and the United States. This, with the active demand for civilian clothing, caused the prices of wool to rise much more than most other commodities.

At the beginning of the year 1920 prices had reached a dangerously high level. And, at about that time, the increase in available shipping, due to the completion of many new vessels and the release of many others from military to commercial service, made

[1] See address of Mr. Albert W. Elliott, *National Wool Grower*, Vol. XVII, No. 2 (Feb., 1927), for a detailed and illuminating discussion of this whole subject.

it possible to accelerate the movement of the great stocks of wool from the Southern Hemisphere to the United States and Europe. This rising inundation of the raw material, at a time when Europe was not yet prepared to resume normal consumption, naturally broke the market, and resulted in the drastic liquidation of values of wool and all products of wool which began in the spring of 1920. It was a veritable wool panic and, like all business panics, caused such great losses and such serious destruction of confidence in

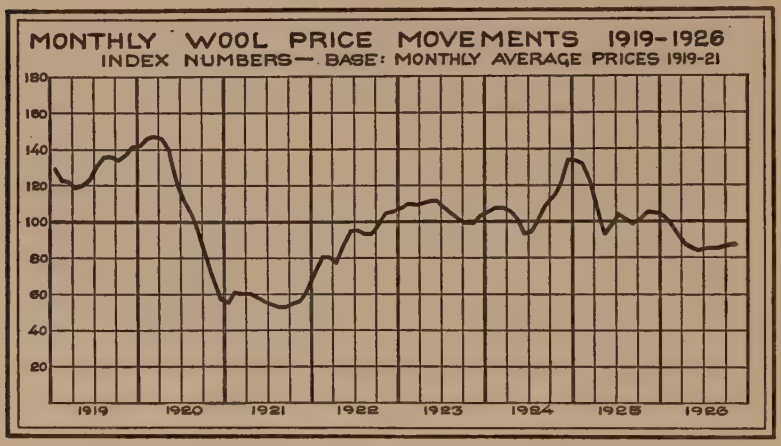


FIG. 9

values that prices were depressed far below normal pre-war times. Wool prices fell to 57 per cent of the pre-war ratio, and this liquidation continued throughout 1920 and 1921. Since the beginning of 1922 a rapid recovery has taken place; and while most other agricultural products for several years have been selling low in comparison with industrial goods, wool has, for most of the period, held an enviable position.

WOOL PRICES AND THE TARIFF

American wool prices depend as much on world-conditions as on domestic supply and demand. While there has been a differential between domestic and foreign wool prices, created by a tariff on wool, other factors than the tariff cause continual varia-

tions of prices between different countries. Therefore, although the tariff may influence the ratio of the domestic wool production to domestic consumption, that ratio is also governed by other factors. Tariff revision in the United States took place many times; yet the changes which might have been expected if the tariff had been the only influence have not usually occurred.

The following summary of price trends is instructive [1]

1860–70: Falling wool prices in 1860 soon changed to high prices, followed by a depression from 1868 to 1870. At the same time English wool prices continued moderate.

1870–90: This twenty-year period coincided with a great expansion of wool production in the Southern Hemisphere, whereby a great excess of wool, equal to one year's normal world-supply, was produced above the amount which the wool-using countries could consume currently. Therefore, wool prices experienced a long decline, with United States prices, relative to other commodity prices, lower than in England, despite high tariff.

1890–96: While general prices continued to decline until 1896, wool broke sharply in 1894, when it was placed on the free list in the face of the lowest prices on foreign markets the world has ever known.

1897–1912: After the tariff act of 1897, wool prices rose, and during the Spanish and Boer wars were relatively higher than those of general commodities. Australia, from 1895 to 1902, reduced its wool supply and aided the price rise. The principal factor, however, was that the world was able to consume annually more than its average yearly production. This slowly enhanced prices; but the 1913 removal of wool duty resulted in a slight decline in American wool prices.

1913–26: The World War caused wool prices to soar, and they were relatively higher than general commodity prices. The removal of the market inside the German lines brought about a surplus of three billion pounds of wool, the pressure of which caused the rapid price decline of 1920 and 1921. The recovery of 1922 and 1923 was due partially to the emergency tariff of 1921 and the Tariff Act of 1922, and partially to better general business conditions throughout the world, which permitted the consumption of about one and one-sixth wool crops each year. Highest prices were reached at the close of 1924, as the end of the world-surplus hove in sight. The wool trade expected still higher levels, but the rising prices not only restricted consumption, but operations slowed up materially, due to the volume of woolen goods manufactured but still unconsumed. As a result, wool prices have gradually dropped since that time.

[1] See Mark H. Smith, *The Tariff on Wool*, Institute of Economics (1926), Appendix A, pp. 297–300.

Domestic wool production does not supply our home demand, for in recent years the domestic supply has comprised only half of the total consumption. The yearly production of wool in this country has been fluctuating around 300,000,000 lb., for forty years, while the total consumption has increased from about 400,000,000 to 600,000,000 lb. Most imported wools come from countries where the cost of production is low. Wool has, therefore, been grouped among the products for which a tariff has been established. Wool has been on the free list only twice, viz., from August, 1894, to July, 1897; and from October, 1913, to May, 1921. It is evident from trade statistics that unusually heavy imports were then characteristic. At the present time the rates of duty are higher than at any other period.

The wisdom of a wool tariff is a matter of controversy between advocates of free trade and upholders of protection as a national policy. In the trade itself, wool producers are high protectionists, while manufacturers of wool textiles are in favor of a more moderate tariff, though not, of course, free trade in wool. The meat packer, standing between the two interests, is necessarily neutral. Regardless of wool prices, competition forces him to pay the producer the full pelt value, and the packer's return is simply a charge for handling. The packing industry has no interest in the problem except to desire such a situation or solution as will mean prosperity to both wool producer and manufacturer. For both must be prosperous to bring maximum prosperity to the wool phase of the operations of the national packing industry. However, the economics of a tariff on wool are of such widespread significance that it is of interest to students of agricultural economics to summarize here the free trade and protectionist points of view.

A recent writer[1] gives the following as the more significant reasons for favoring the free entry of wool: (1) Wool is an essential raw material, the domestic supply of which is insufficient, and a duty raises the cost of living. (2) The duty has not greatly stimulated sheep and wool production. (3) Removal of the duty could have little permanent effect on domestic production. (4) Even if

[1] Mark A. Smith, *The Tariff on Wool*, Institute of Economics.

the duty stimulated production, its value to growers would be largely nullified by the ensuing larger production of, and lower prices for, lamb and mutton. (5) Future increases in wool production will take place on farms because range production has passed its zenith; on farms sheep and wool are of secondary importance. Keen competition has to be met from other uses for the land; lamb sales are of far greater importance than wool, and farm production, therefore, is largely independent of the tariff. (6) The vested rights argument is without force. (7) Other factors, particularly the land question, greatly outweigh the tariff. (8) The need for wool as a military necessity is easily cared for. (9) A duty on wool necessitates a compensatory duty on cloth, and complicates the competitive situation for the manufacturer. (10) The duty on wool is greatly pyramided, imposing a heavy burden on consumers of wool textiles. (11) This cost is so much greater than the direct benefit derived by wool growers and the relatively unimportant revenues received by the government, as to make a wool duty indefensible.

On these arguments or points another student of the industry,[1] not an avowed protectionist himself, makes the following comment, point by point:

1. There is no question that wool is an essential raw material; that the domestic supply is insufficient; that the duty raises the domestic price; and that, to this extent, the cost of living tends to be raised. This may or may not constitute a valid argument for free wool.

2. While the duty has not increased the domestic wool clip since the middle eighties, the duty may have stimulated production to a much greater extent than indicated, e.g., in the Rocky Mountain region. Entirely aside from the question of whether up to 1900 a wool duty had been the best policy for the country as a whole, it would seem clear that the tariff had markedly stimulated sheep and wool production until 1893, at least in all but the Rocky

[1] Louis G. Connor, of the staff of the United States Tariff Commission, *Bulletin of the National Association of Wool Manufacturers*, Vol. LVI (October, 1926).

Mountain region, and that it did so for the Rocky Mountain region after 1896. If the wool duty, as is generally believed, raised domestic prices by 7 cents per grease pound, or about 33 per cent from 1897 to 1913, then it follows that the tariff was of considerable importance to the range sheep industry. Since 1922 the duty on wool would seem to have been a decided and stimulating benefit to the range industry.

3. It is rather a broad assumption to state that the removal of the tariff would have little permanent effect on the domestic sheep industry. Such a conclusion is largely conjecture, and is not based on the actual facts in wool growing history in this country.

4. Any price decline in sheep and lambs would be appreciably tempered by the effect of the tariff on wool prices, if the wool duty were retained. The more lamb prices decline, the more important the duty on wool would become to sheep raisers.

5. While a future large increase will probably take place on farms rather than on ranges, considerable gains can take place on the latter, and are now being made. Although sheep and wool are tending to be of secondary importance on farms, the value of wool receipts in total flock receipts on general farms is practically the same as that of meat production. Therefore, the value of a wool duty to farm sheep raising is significant.

6. To the conclusion that the claim of vested rights is without force, it is pointed out that it is a matter requiring more careful study. In the Rocky Mountain region a large part of the relatively small area of crop land is irrigated. The bulk of the crops for at least two-thirds of these lands is used mainly by stockmen to supplement their restricted ranges, and this outlet is of increasing importance. In this development sheep have played a great part, and the industry has been encouraged by the government through its irrigation and settlement policies.

7. Regarding the argument that other factors, particularly the land question, greatly outweigh the tariff, it is also pointed out that these important factors all really center on the land question, which itself is a result primarily of the homestead entry on the open ranges. Due to the government's grazing homestead policy

in recent years, many settlers suffered great losses and have been disappearing; but in spite of handicaps the sheep men have held on, and they held on in order to put to profitable use the otherwise unusable, or only partly usable, grazing lands.

8. The argument that the need for wool as a military necessity is easily cared for, is open to serious question. During the great war, the rigor of the measures taken by the allies to conserve wool supply for military needs, the meagerness of the issues for civilian consumption, and the care taken to prevent supplies reaching the enemy indicate that experts consider wool supply a difficult war-time problem.

9. Regarding the point that a duty on wool requires a compensatory duty on cloth, this is unquestioned. Our manufacturers need a protective duty, perhaps even as high as 50 per cent, on fabrics. Removal of the duty would in no way alter this protective need, which makes it entirely impracticable for manufacturers to compete in the export trade in wool textiles.

10. The free trader's point that the duty on wool is greatly pyramided, imposing a heavy burden on consumers of wool textiles, is merely an assertion. The free trader's estimates of the cost of the wool duty err in these particulars: (*a*) His preliminary assumption that the duty is fully effective on domestic wool prices is not a fact. (*b*) The highly important differences between woolens and worsteds are nearly ignored. (*c*) The pyramiding assumption is inaccurate. (*d*) No attempt is made to evaluate the effect on cloth and clothing of increases in cost, other than for the raw material alone. (*e*) The effect of the wool duty on world-prices is overlooked. To the extent that the duty results in an increase in the domestic wool clip, the world-supply of wool is increased and the world-price is depressed below the level which would prevail if there were no duty. Only an indeterminate part of the excess of domestic over foreign prices as a result of a duty on wool, therefore, can be used in an attempt to calculate the real "cost" of the duty. In the nature of the case, this real "cost" is less than would be suggested by the amount of the excess of domestic over foreign wool prices.

11. To the statement that the cost of a tariff is much greater than the benefit to wool-growers, the comment may be made that this is merely a statement of opinion, and not a conclusion from facts; for no one can arrive statistically at the true cost of the duty, or, for that matter, the benefits. Any true cost must be a net figure, a result of balancing benefits against costs.

In times past there have been periods of depression, owing to agitation for a removal of the wool duty and the probability of it. Then, after a period of free wool, has come the certainty of a restoration of the duty and heavy importations of raw wool and wool manufactures, which have taken one or more years to dispose of. In the meantime, the increase in domestic wool production, worked for as a result of the duty, has been delayed. If practicable, this "political football" character of the wool duty should be eliminated. Then advantage should be taken of the present opportunity for moderate protectionists to arrive at definite conclusions concerning the real effect of a duty on wool in stimulating sheep and wool production, and, as a result of it, its real value in relation to a broad national policy regarding the protective principle as applied to essential raw materials.

In brief, free traders usually argue that a wool duty is no longer necessary for public defense, for the protection of an infant industry, or for further diversified production. While this may or may not be true, the present tariff was applied to administer relief to wool producers in a depression which could not be foreseen. At present the duty cannot be lowered without decreasing the price of wool, and such reduction would bring loss to all wool-growers.

By-Products of Wool

The processing of wool, itself a by-product, results in many other by-products of commercial value and use. The mere washing of wool may yield what is apparently dirty water, but in reality it contains material of considerable value. By far the best example is the grime washed from a sheep's fleece. This contains a certain amount of potash, which exudes through the skin and adheres to the wool. In cleaning the wool this was at one time all lost, and even now much of it is recklessly washed away. The

more economical wool-cleaning establishments, however, save the wash water and employ chemists to remove the potash. Likewise, the wool fat and wool perspiration are useful for many pharmaceutical purposes.

The by-product recovered from the scouring or degreasing process is valuable. It is refined into a product known as lanolin, which is the base from which many ointments are made. Previous to the war it was considered necessary to import practically all lanolin used in the United States, but now American manufacturers produce it in this country. After having been degreased, carded, woven into fabrics, cut and sewed into clothes, yet other by-products are secured from wool. When woolen clothes are tattered and rent they are sold to a manufacturer who tosses them into a machine by which they are completely picked to pieces. The product of that picking is wool which, although not equal to new wool, may nevertheless be used again. The threads are shorter than originally, but are still long enough for the weaver. Mixed with virgin wool they can once more do service in a fabric. Woolen goods often contain admixtures of cotton. When the wool wears off and the tightly twisted cotton makes its appearance, the fabric is again picked to pieces and the cotton removed by treatment with sulphuric acid, yielding a product known as shoddy. Were it not for shoddy, there would not be enough raw material to meet the clothing demands of the American public, except at greatly increased prices. After absolutely nothing is left of a woolen fabric that can be spun or woven into a new textile, the wool is mixed with hoofs, horns, and blood from packing plants, and it is then combined with wood ashes and scrap iron to form a base out of which the dye, Prussian blue, is made.

A method has been patented for extracting no less than five valuable products from wool fat, which are employed as bases for ointments and cosmetics, leather dressings, and fiber lubricants. The fat removed amounts to about 15 per cent of the wool treated, which, at a minimum price of 3 cents a pound, means 45 cents on every 100 lb. of wool degreased. If to this is added the value of the carbonate of potash recovered from the rinsing waters, which averages 25 cents for every 100 lb., 75 cents is the

minimum value of the by-products removed from every 100 lb. of raw wool. Before the solvent method of wool degreasing was introduced, it is estimated that between two and three million dollars worth of wool fat and potash were annually wasted in the United States.

Curled Hair

Hair as a by-product of the packing plant has been of great use to the furniture and automobile industries. In 1925 four million additional dollars were paid to producers of livestock in the United States, due to the commercial value of cattle hair. It is of special interest in the making of automobiles, which industry provides its biggest outlet. The greater speed developed by automobiles has made it necessary to provide more comforts, and curled hair was adopted as the filler for seats and cushions. The advantages that curled hair possesses are: (1) curled hair is permanently resilient; (2) it is permanently soft; (3) it is non-heating; (4) it is non-absorbent. Curled hair from cattle is usually clipped from the tail, and the strands vary from 6 inches to more than a foot in length. The switches of longer hair on the ends of the tails are sorted into black, white, and gray colors, spun into short ropes, boiled, steamed, baked, and then untwisted and fluffed out. This long hair is often sold to mattress makers as well as to automobile manufacturers.

The disposition of hog hair has been a serious problem, as its uses are innumerable and are constantly increasing. Chief among them are stuffing for upholstered furniture, e.g., mattresses and davenports, and automobiles; insulation, such as refrigeration lines, tanks, etc.; and for building material. The early crude method of treating hair was to wash and separate it from the scurf, toes, and dirt, and spread it out on the fields adjacent to a packing plant, where it was allowed to dry in the sun and wind. This was, and is still, known as field-dried hair. Today, with exhaust steam available, it has become the custom to use this agency to produce coil-dried hair. This system of drying consists of arranging a series of flat coils to suit any available area. The coils are covered with heavy screening on which the washed hair is spread, thus giving the excess water full opportunity to drain off,

CURLED HAIR IN STRANDS

MATTRESS AND FURNITURE SHOWING CURLED-HAIR STUFFING

and the hair is heated with coils by means of exhaust steam. The drying is continued until the moisture content of the hair is reduced to 12 per cent or less. Then the hair is baled by means of ordinary baling machines, and is known as crude coil-dried baled hair. Such a method is usually employed where production does not justify the installation of the more elaborate equipment for drying, curing, dyeing, and curling.

In plants with large production the hair is taken from the dehairing machine to a vat of cold water, eliminating as much dirt, scurf, and toes as possible. If the production is such as to necessitate the holding of the hair for several days, the water is changed several times, is kept constantly cold, and in summer is iced. A bright, glossy, resilient hair is desired, and this effect is entirely destroyed when water is stagnant and warm. When the hair is cooled and washed, a solution of sodium hydroxide (76 per cent solid caustic soda) is added. The exact amount of caustic soda needed is determined by the condition of the hair at this point, the methods of handling, and the use to which the hair is ultimately to be put. The contents of the vat are then agitated and heated with open steam until the boiling point has been reached. The steam is then reduced, and the contents of the vat are allowed to simmer for from three to six hours, or until the cuticle becomes slimy and slips easily away from the hair. Some plants bring the contents of the vat to a boil and then cut off the steam altogether, allowing the contents to "cure" for several hours. Caustic soda in the water liberates the nitrogen or ammonia in the hair, and the smaller the amount of soda used, the glossier and more satisfactory will be the hair.

After curing, the hair is fed through a horizontal washing and picking machine, operating at a speed of about 500 revolutions per minute, the interior of this machine being strongly fed with hot water and steam. This picking operation is repeated two or three times until the hair is thoroughly cleaned and separated from the cuticle. Finally, the clean hair is loaded on trucks and conveyed to drying rooms.

Drying rooms are sometimes made absolutely tight and fireproof, the heat being introduced from coils by means of a fan

through perforated plates in the floor or walls, the exhaust being in the ceiling. The time of drying is from three to six hours, according to the thickness of the hair on the trucks, the size of the room, the coil space steam pressure, and the thickness and disposition of hair on the truck. The layers of the hair are not over 10–12 inches thick, and a free circulation of heated air through the hair is provided for. Some systems of continuous drying, which are very satisfactory, are in use by large operators. After drying, the entire equipment for hair treating is thoroughly cleaned and sterilized. The dry cured hair is then baled and disposed of, or dyed and further processed.

The dyes most commonly used for hair treatment are hematin, commonly called logwood extract. About 9½ oz. of hematin are used for every 100 lb. of wet hair dyed. The hematin is dissolved in the water and is mixed thoroughly in the vat before the hair is placed in the water. While the hair is in the vat, the contents are thoroughly agitated and boiled for about half an hour. Hematin produces a jet black hair, and in order to produce a blue-black hair experiments are being made with aniline dyes. These dyes, both acid and direct, are being used today for dyeing hair.

Some plants are provided with winnowing machines, which have the effect of "fluffing" the hair, which is very desirable when used for certain purposes. Other plants have curling machines, whereby the hair is twisted into strands or ropes for the purpose of curling. This twisting and curling was formerly done by hand.

Hog bristles are very scarce in the United States. Few plants find it profitable to pull the bristles. Those that process bristles generally do so in winter. The white and black bristles are kept separately and are treated by the same method as that described for the treatment of hair, except in the dyeing process, and are sold to the manufacturers of hair brushes. However, at present most hog bristles used in the United States are imported from Europe. One of the picturesque details of by-products in the packing industry is the use made of the delicate hairs on the inside of a cow's ears. These are manufactured into artists' brushes, a substitute for the camel's-hair variety, and thus contribute beauty to American civilization!

CHAPTER IV

FATS, OILS, AND GREASES

Fats, oils, and greases are, from many points of view, the most important by-products of the packing industry because of the wide variety of commodities into which they go as major or minor ingredients or constituents. Their economic significance was made plain in a dramatic way during and after the World War, when American fats and oils saved European countries from what might have been the worst famine since the Thirty Years' War. To appreciate the significance of the fats, oils, and greases which are produced from packing-house operations, something must be known of their chemistry, the sources from which the principal commercial fats and oils are derived, the causes of the difference between edible and inedible fats, and the meaning of certain technical terms used in trading in fats and oils. From this basis there can be made an intelligent study of the methods of manufacture of fats and oils, which include refining, bleaching, deodorizing, and transformation of the crude materials into finished products for edible and inedible uses.

In general, human food can be divided into three classes: nitrogenous, or flesh-forming foods; carbonaceous, or energy-producing foods; and minerals. Fats fall in the carbonaceous group, along with the carbohydrates, such as starches, sugars, gums, etc. The essential difference between fats and carbohydrates lies in the relative volumes of energy which they yield. In both groups the predominating chemical elements are carbon, hydrogen, and oxygen; but in fats the ratio of carbon and hydrogen to oxygen is much higher, and the consequent yield of energy under combustion or in nutrition is greater. As a rule, fats yield two and one-fourth times as much energy as carbohydrates.

Fats and oils, like other chemical compounds, are composed of a basic constituent with which acid constituents are combined. In fats this basic factor is glycerine, which has the property of

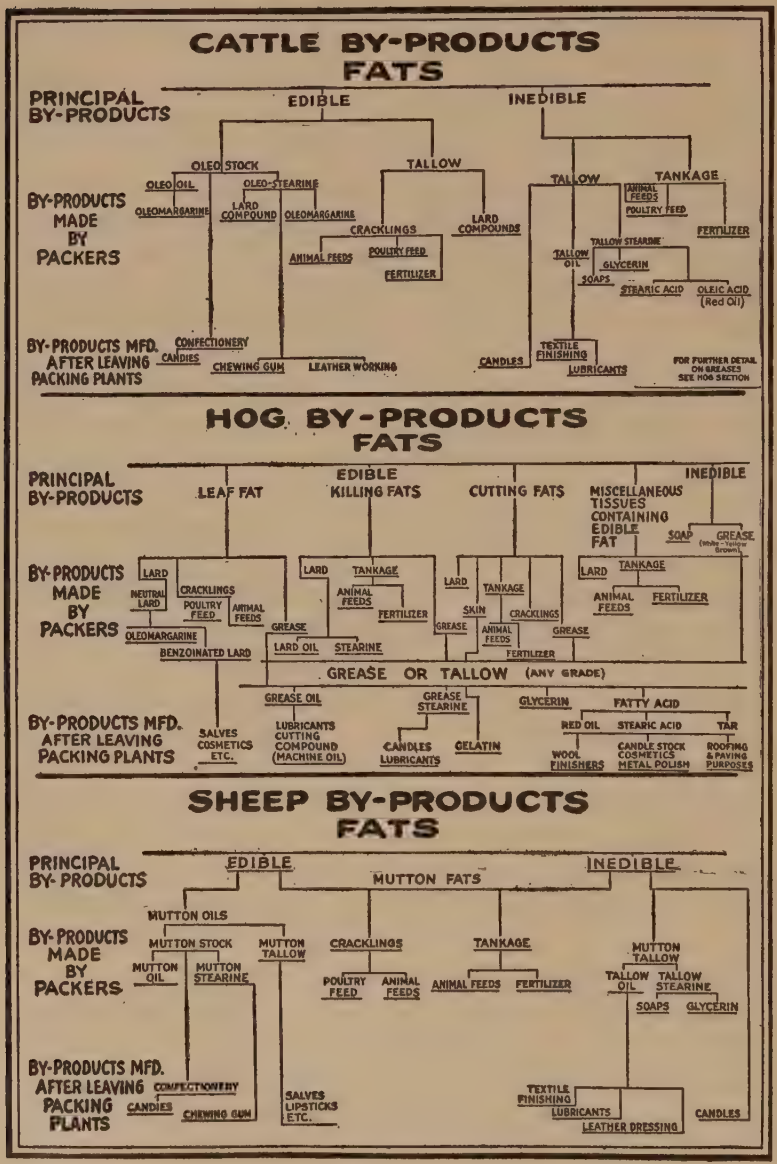

CATTLE BY-PRODUCTS
FATS
PRINCIPAL BY-PRODUCTS
EDIBLE
INEDIBLE
OLEO STOCK
TALLOW
TALLOW
TANKAGE
OLEO OIL
OLEO-STEARINE
ANIMAL FEEDS
POULTRY FEED
BY-PRODUCTS MADE BY PACKERS
OLEOMARGARINE
LARD COMPOUND
OLEOMARGARINE
CRACKLINGS
LARD COMPOUNDS
FERTILIZER
ANIMAL FEEDS
POULTRY FEED
FERTILIZER
TALLOW STEARINE
TALLOW OIL
GLYCERIN
SOAPS
STEARIC ACID
OLEIC ACID (Red Oil)
BY-PRODUCTS MFD. AFTER LEAVING PACKING PLANTS
CONFECTIONERY
CANDIES
CHEWING GUM
LEATHER WORKING
CANDLES
TEXTILE FINISHING
LUBRICANTS
FOR FURTHER DETAIL ON GREASES SEE HOG SECTION
HOG BY-PRODUCTS
FATS
PRINCIPAL BY-PRODUCTS
LEAF FAT
EDIBLE KILLING FATS
CUTTING FATS
MISCELLANEOUS TISSUES CONTAINING EDIBLE FAT
INEDIBLE
SOAP
GREASE (White - Yellow - Brown)
BY-PRODUCTS MADE BY PACKERS
LARD
NEUTRAL LARD
CRACKLINGS
POULTRY FEED
ANIMAL FEEDS
OLEOMARGARINE
BENZOINATED LARD
GREASE
LARD
TANKAGE
ANIMAL FEEDS
FERTILIZER
LARD OIL
STEARINE
LARD
TANKAGE
SKIN
CRACKLINGS
GREASE
ANIMAL FEEDS
FERTILIZER
GREASE
LARD
TANKAGE
ANIMAL FEEDS
FERTILIZER
GREASE OR TALLOW (ANY GRADE)
GREASE OIL
GREASE STEARINE
GLYCERIN
FATTY ACID
RED OIL
STEARIC ACID
TAR
BY-PRODUCTS MFD. AFTER LEAVING PACKING PLANTS
SALVES COSMETICS ETC.
LUBRICANTS CUTTING COMPOUND (MACHINE OIL)
CANDLES LUBRICANTS
GELATIN
WOOL FINISHERS
CANDLE STOCK COSMETICS METAL POLISH
ROOFING & PAVING PURPOSES
SHEEP BY-PRODUCTS
FATS
PRINCIPAL BY-PRODUCTS
EDIBLE
MUTTON FATS
INEDIBLE
MUTTON OILS
BY-PRODUCTS MADE BY PACKERS
MUTTON STOCK
MUTTON TALLOW
CRACKLINGS
TANKAGE
MUTTON TALLOW
MUTTON OIL
MUTTON STEARINE
POULTRY FEED
ANIMAL FEEDS
ANIMAL FEEDS
FERTILIZER
TALLOW OIL
TALLOW STEARINE
SOAPS
GLYCERIN
BY-PRODUCTS MFD. AFTER LEAVING PACKING PLANTS
CONFECTIONERY
CANDIES
CHEWING GUM
SALVES LIPSTICKS ETC.
TEXTILE FINISHING
LUBRICANTS
LEATHER DRESSING
CANDLES

FIG. 10

holding three molecules of the fatty acids. The natural glycerides, for the most part, do not yield three molecules of the same fatty acid (triglycerides), but instead are mixed glycerides yielding different fatty acids, such as di-stearo-palmitic, di-palmitic-stearic, stearo-palmitic, oleic, etc. Exact knowledge of the fatty acid content of various fats and oils is imperfect, due to the difficulty of exact separation of the fatty acids. Fats are not particularly stable compounds, and they require careful treatment in order to prevent chemical changes from taking place within them. By slight rearrangements of the atoms within the molecule, larger or smaller numbers of atoms of carbon and hydrogen may be included.

Fats are subject to two principal decompositions: hydrolysis, which yields glycerol and fatty acids; and rancidity, which is an oxidation process that produces aldehydes and less complex fatty acids of disagreeable odors. In general, hard fats contain larger proportions of carbon and hydrogen in relation to oxygen than do the lighter fats and oils. Furthermore, broadly speaking, the heavier fats are more nearly saturated, i.e., they are more nearly stable and less subject to rearrangements in their molecular structure, which permit the addition or subtraction of further chemical radicals within the molecule. The degree of saturation is measured by the so-called "iodine number," which indicates the possible degree of rearrangement of the atoms within the molecule so as to take up more chemical radicals. The fewer of these that can be absorbed, the lower is the iodine number, and vice versa. One of the great modern discoveries in the manufacture of fats is the process of hydrogenation, which makes fats harder by adding the hydrogen atom at different points in the fat molecule, to produce greater stability in its structure.

Classification of Fats and Oils

Fats and oils are usually grouped according to origin, their degree of saturation as indicated by their iodine values, or the proportion of volatile fatty acids they contain. Therefore there are three main divisions, viz., mineral, animal, and vegetable fats,

each of which is subdivided into liquid fats or oils, and solid fats. The vegetable oils are grouped into three classes: non-drying, semidrying, and drying oil, in accordance with their behavior on exposure, in a thin film, to the air. They are also classified into those which approximate coconut oil and palm-kernel oil in containing large proportions of volatile fatty acids, and vegetable tallows, such as cocoa butter, characterized by their higher proportion of non-volatile insoluble fatty acids.

Animal oils, such as neatsfoot oil, etc., are the more fluid fats derived from certain parts of animals. Animal fats are, in most cases, of the type of lard, or of tallow, and their constituents depend largely upon the part of the animal from which they are obtained. Certain fats of this class, notably those of wild animals, show pronounced drying properties, forming a hard film when exposed to the air in a thin layer.

An oil is a substance possessing one or more of the following characteristics: (1) liquid at ordinary temperatures with a smooth unctuous feeling; (2) insoluble in water; and (3) specifically lighter than water. In recent years the conversion of fluid oils into solid fats by hydrogenation may be regarded as the most significant advance in the industry. This process is accomplished by means of a catalyzer nickel or oxide of nickel which causes the hydrogen to be absorbed by the unsaturated compound. Originally, hydrogenation was used for technical purposes, for example, soap making and the manufacture of candles. Later, the process was perfected so that all kinds of oils could be hardened, and they are now used in the manufacture of margarine, lard, compound, etc.

Animal fats are closely related, both in chemical and physical properties, to the vegetable fats. They are secreted by animals in various parts of the body, where they serve partly as food reserve and partly as protective layers against climatic conditions. Their composition varies according to anatomical location. The fats associated with the internal organs usually contain a larger portion of unsaturated glycerides than those in the connective tissues. Their composition is also affected by climatic conditions. For ex-

ample, animals living in warm climates invariably have fats of a higher melting point, (i.e., containing more saturated glycerides) than those of members of the same species living in colder climates. The diet of the animal also affects, to some extent, the composition of the fat. Thus, hogs fed upon cereal grains produce a harder lard than do hogs fed upon corn, while diets containing a large proportion of cottonseed, peanuts, or soy beans, produce a fat showing definite chemical constants indicating the presence of cottonseed oil or the other feeds. In general, the fatty tissue of animals contains from 59 to 65 per cent of fat. The remainder of this tissue consists of the cells of connective tissue and a certain percentage of moisture. For example, leaf fat ordinarily contains 95 per cent lard, 4 per cent moisture, and 1 per cent fiber, by proximate analysis.

There is no doubt that animal fats, along with flesh, were used for food by primitive man. Later other uses were discovered, such as fats for burning and illumination, for application to the body to enable it to withstand bad weather, for impregnating clothing, etc., to make it soft, supple, and waterproof. Finally, in very recent times their technical use was developed for soap making, candles, etc. The by-products obtained in the working up of fat play an important part, this being especially true in the case of glycerine, which is now produced in enormous quantities. While fifty years ago the glycerine formed during saponification was simply allowed to run to waste along with the lye, it is today a highly important article of commerce on account of its diversity of uses. Both medicinal glycerines of high grade, and several lower qualities for industrial use, are being made on a very large scale.

Until comparatively recently, the method of preparing animal fats was quite primitive, the crude fat being melted or "rendered" in open pans heated by direct fire, either with or without water, perhaps melted again for purification, and afterward placed on the market. Up to a few years ago, the odors from rendering were unpleasant, especially before the days of the dry rendering process. Due to this new process unpleasantness from odors has now been eliminated.

All fats are chemical compounds formed from glycerine and fatty acids, such as linoleic, oleic, stearic, and palmitic. In some fats the balance between the fatty acids and glycerine is so nearly perfect that there are no free fatty acids, and the fat is said to be "neutral." This fatty-acid content is important in determining whether the product is a fat or an oil. If at ordinary temperatures the product is liquid, then it is an oil. The fact that it is liquid is due to the predominance of the glycerides of the unsaturated fatty acids, e.g., linoleic and oleic acids. But if the product is a solid at ordinary temperatures, it is a fat. This means that there are enough radicals of palmitic and stearic acids in the product to raise its melting-point above normal temperatures.

The largest part of animal fats and oils used in commerce is naturally produced by the packing industry. For example, from the slaughter of cattle are obtained oleo oils, oleo stearine, and edible tallow, the higher grades of which are processed, resulting in such products as oleomargarine and compound used for edible purposes. The lower or inedible tallow grades are manufactured into soaps, lubricating oils, cup greases, and cutting compounds. From the slaughter of hogs are derived the various grades of lard and inedible greases which find uses similar to tallow.

A fundamental distinction in the production and sale of animal fats and oils is that drawn between edible and inedible products. The first factor is the proper and careful selection of the parts from which the fat is to be rendered. Among those parts from which the fat is classed as edible are large pieces of fat, such as caul in cattle, or leaf and back fat in hogs, trimmings from edible portions of meat: in brief, all fat which is not contaminated by offal during slaughter. Inedible fat includes condemned carcasses, fat from diseased parts, and fat from guts, pecks, and rennets, sweepings, and clean-up scraps. Such fat is rendered inedible by impurities which affect the flavor, increase the free fatty acids, or darken the color. The second factor is time, which makes it necessary to render fats promptly in the tank room to prevent decomposition. The third factor in determining the grade of fats and oils is the method of rendering. For example, fats rendered at

a low temperature are more neutral in flavor, have less free fatty acids, and surpass in quality fats rendered at higher temperatures or under pressure. The fourth factor is the proper removal of moisture and impurities, which is accomplished by settling carefully at a relatively low temperature and by bleaching, i.e., the removal of nitrogenous bodies and water to render the product stable. A fifth factor is the method of storage, for cool dry storage space prevents deterioration.

Three terms are of importance in the manufacture and sale of fats and oils. They are free fatty acid content, titer, and M.I.U. All inedible oils are bought and sold with a specified maximum free fatty acid content. When fat is still inclosed in nitrogenous cells within the animal's body, the fat is neutral, containing no free fatty acids. But rendering permits the fat to separate from the connective tissue, and if the fat is acted upon by water in the presence of heat, or by enzymes, the glycerine is split away and the fatty acids are freed. These fatty acids react like mineral acids, though not as actively. Inedible fats are made undesirable for the soap-maker if they contain free fatty acids. In brief, the free fatty acid content determines the quality of a fat or oil. If it is low, the fat has been prepared from fresh stock and has been handled in a careful manner. Free fatty acids may be removed by refining the oil or fat with caustic soda, soda ash, or other alkaline substances.

Titer is an indication of the hardness of an oil, and it is determined by splitting up a portion of the fat or oil with caustic soda into fatty acids and glycerine. The temperature point at which fatty acids crystallize or solidify is known as the titer of the fat or oil. Hard fats have high titers and liquid oils have low titers. By a titer test, a soap-maker can tell whether the resulting soap will lather easily, since soaps from high-titer fats require higher temperatures.

The letters "M.I.U." are merely an abbreviation for the words, "moisture, impurities, and unsaponifiable matter," and measure the purity of the raw materials.

Disposition and Manufacture of Pork Fats

In the manufacture of fats and oils, chemical control is absolutely necessary. First of all, the fats must be preserved in their entirety, by which means decomposition is avoided; e.g., by rendering the fats fresh. Second, the fats must be kept pure and wholesome by avoiding contact with light and air. Fats and oils are very delicate and can easily be spoiled for use. Probably less is known about the manufacture of fats and oils than about any other field of applied chemistry, and there is much improvement to be made. In processing fats the following fundamental principles are of utmost importance:

1. Decomposition must be prevented, either by rendering immediately after slaughter, or prompt chilling if the fat must be held over. In case these precautions are not taken, bacteria develop rapidly and set up a disintegration that splits the glycerine and fatty acids apart. Furthermore, the proteins are decomposed so as to produce free nitrogen and ammonia, thereby reducing the content of this element in the resulting tankage.

2. Extreme heat pressure or exposure to air and light must be avoided during manufacture, since each of them also contributes to decomposition and produces oxidation.

3. Moisture and impurities must be removed, for the same reason.

4. Tests for free fatty acids must be run during each stage of manufacture, both as a check on the condition of fats and as an index to remedial measures.

5. Schedules of storage and manufacturing temperatures must be prepared and followed rigidly to produce the required chemical results and physical textures. For example, oleo oil must be held within narrow temperature limits in order to "seed," or granulate, in a form similar to butter.

In the manufacture of animal products in a packing plant, beef fats are processed separately from pork fats, the former coming under the head of beef operations, and the latter under the head of pork operations. This applies to both edible and inedible fats. Animal fats have always been separated from tissue by ap-

plying heat with various means. However it was done, the process has been known for a long time as rendering. In the case of all the fats, methods of rendering are similar.

Rendering Lard

As the fats or glycerides exist in animal tissue, they are neutral, i.e., they contain no free fatty acids, but the means of hydrolysis are at hand, since moisture is present, and lipase, the fat-splitting enzyme, is very generally distributed through the free fatty tissue. Immediately after the death of the animal, fatty acids begin to make their appearance, and almost every step in the rendering and after-treatment of fat tends to produce more and more free fatty acids. It is the chief aim of the rendering processes to prevent hydrolysis and to keep the free fatty-acid content low. Free fatty acids increase progressively and readily up to about 40 per cent. During the period when moisture is present in dry rendering, and throughout the process of steam rendering, free fatty acids are produced, although in small quantity. The lard or oleo stock from kettle rendering processes usually contains from 0.1 to 0.3 per cent free fatty acids calculated as oleic, which is the custom; while lard from steam rendering contains from 0.5 to 0.75 per cent.

Technically speaking, "rendering" is a term applied to the melting out of fat from fatty tissue and, in packing-house practice, is accomplished by the following processes, with the logical products resulting therefrom indicated in each case:

1. Low-temperature dry rendering produces
   (*a*) Neutral lard
   (*b*) Oleo stock and oil
2. Ordinary dry rendering produces
   (*a*) Kettle-rendered lard
   (*b*) Dry-rendered lard
   (*c*) Dry-rendered tallow
3. Steam rendering produces
   (*a*) Prime steam lard
   (*b*) Tallow and grease

4. Rendering by heating in water produces
   (*a*) Head tallow, mutton tallow
   (*b*) Neatsfoot oil, etc.

Lard may be defined as the fat separated for use as food from the adipose tissues of the hog.

Fats used in the manufacture of lard are known as killing and cutting fats, the killing fats being produced at the time of slaughter and handled hot and fresh, and the cutting fats coming from the cutting floor, after the carcass has been chilled. Animal fats are relatively soft on the back, around the loins, and in the exposed parts of the animal, since they are exposed to the outside temperature, which averages much lower than the temperature on the inside of the animal itself. These form the cutting fats. The killing fats, which are maintained at body temperature and which average over 30° F. warmer than the outside temperature, are much harder than the cutting fats. For example, some of the cutting fats melt at as low a temperature as 36° C, while the leaf fat, which is a killing fat taken from under the ribs of the animal, does not melt until 41° C. The lard refiner sees to it that the harder "killing lard" is mixed with the softer "cutting lard" to produce lard of desired hardness.

Commercial Grades of Lard

As pure lard constitutes about 12 per cent of the hog, it is an important factor in the money yield in marketing pork products. Three commercial kinds of lard are manufactured in the United States, viz., prime steam, kettle rendered, and neutral lard.

Steam lard is made by placing the raw materials in a cylindrical steel tank built to withstand pressure, closing all openings in the tank except one small vent, and then injecting steam under 40-lb. pressure into the tank. This action is continued until the pressure inside the tank becomes 40 lb., and for as much longer as is necessary thoroughly to separate the pure lard from the original raw material. The cooking of the material by direct contact with the steam distinguishes this method of rendering from all others, and gives the resulting lard the name "steam lard." The color of

this lard varies with the nature of the material rendered, but in general it is lighter than when other methods of rendering are

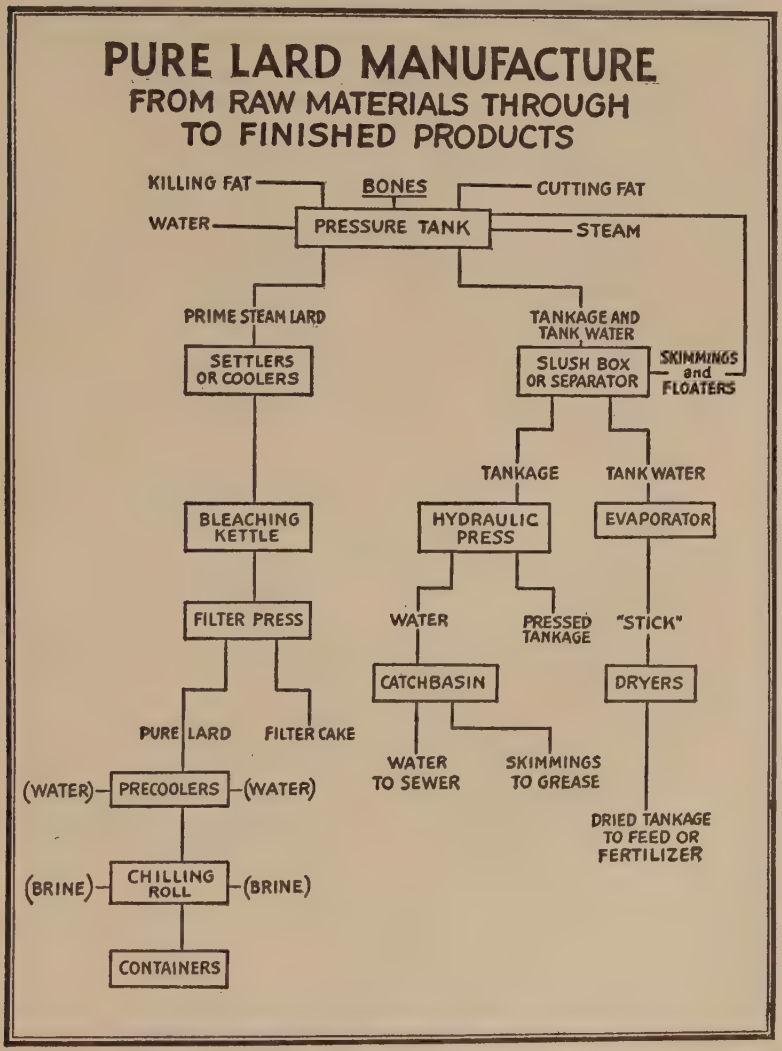


FIG. 11

employed. This method is adapted to the handling of all fatty portions of the hog which are considered suitable for edible pur-

poses. Steam lard may be processed further before being packaged, and in this case it is known as refined lard. The bulk of lard manufactured in the United States is made by this process.

Steam lard made from fresh hog fat is termed "prime steam lard," for which the Chicago Board of Trade specifications (considered standard) are as follows:

> Prime steam lard shall be solely the product of the trimmings and other parts from hogs rendered in tanks by direct application of steam and without subsequent change in grain or character by the use of agitators or other machinery, except such change that may unavoidably come in transportation. It must have proper color, flavor, and soundness for keeping, and no material which has been salted must be included. The name and location of the renderer, the date of packing, and the grade of the lard shall be plainly branded on each package at the time of packing.

Kettle-rendered lard is made by hashing the raw fats into a steam-jacketed kettle and boiling out the moisture in the fats. The resultant lard is then separated from the dry fiber, and while hot is usually filled into packages without further processing. Its color is somewhat darker than that of steam lard made from similar raw material, and yields of lard obtained by this method are also somewhat smaller. Only the better grades of fat from the hog are used as raw material in manufacturing kettle-rendered lard. And kettle-rendered lard usually has the best flavor for cooking purposes.

Neutral lard is made by first chilling raw fat, hashing it into a water-jacketed kettle, and melting the fat from the fiber by the slow heating of the water in the jacket. Both leaf lard and back fat are the raw materials used. The lard obtained by this process is white in color and bland in flavor (in fact, almost flavorless), and is used, with further processing, in the manufacture of margarine.

Lard, like most natural products, shows wide variations in its chemical and physical characteristics, and this increases the difficulty of basing definite conclusions as to purity on the results of analysis. Even in the case of the same animal, wide variations are observed in the types of lard derived from the different parts of the body.

Lard consists principally of glycerides of stearic, palmitic, lau-

ric, and myristic acids, and of the liquid fatty acids, such as oleic and linoleic acids. The different physical properties of several samples of lard are due, in the main, to variations in the proportions of these different constituents. For instance, the firm fat from the leaf or kidneys of the animal contains fatty acids with a considerable percentage (about 20 per cent) of stearic acid, and a low percentage of oleic acid; while the fat from the neck and back, which is very soft, contains fatty acids with about 9 per cent of stearic acid.

Yields of lard obtained from different raw materials vary greatly. Below is a list of the different materials and their yields:

	Percentage
Caul fat	75
Ruffle fat	60
Gut fat	45
Belly trimmings	65
Back bones	12–16
Cheek-meat fat	34
Leaf lard	92–94
Neck bones	13–17
Sweet pickle ham bones	16–19
Clear plates	79–82
Ham facings	75
Snouts (trimmed)	27
Fat back skins (fleshed)	5–11
Neck fat	70
Stomach (well trimmed)	6
Ears	12–14
Lips	26–29
Jaw bones (lower)	11–13
Skull bones	12–14
Hind feet	14–16
Fore feet	10–11
Fat backs	
6– 8	81½
8–10	82¼
10–12	83½
12–14	84½
14–16	85½
16–18	86¼
18–20	86¾
20–25	87½

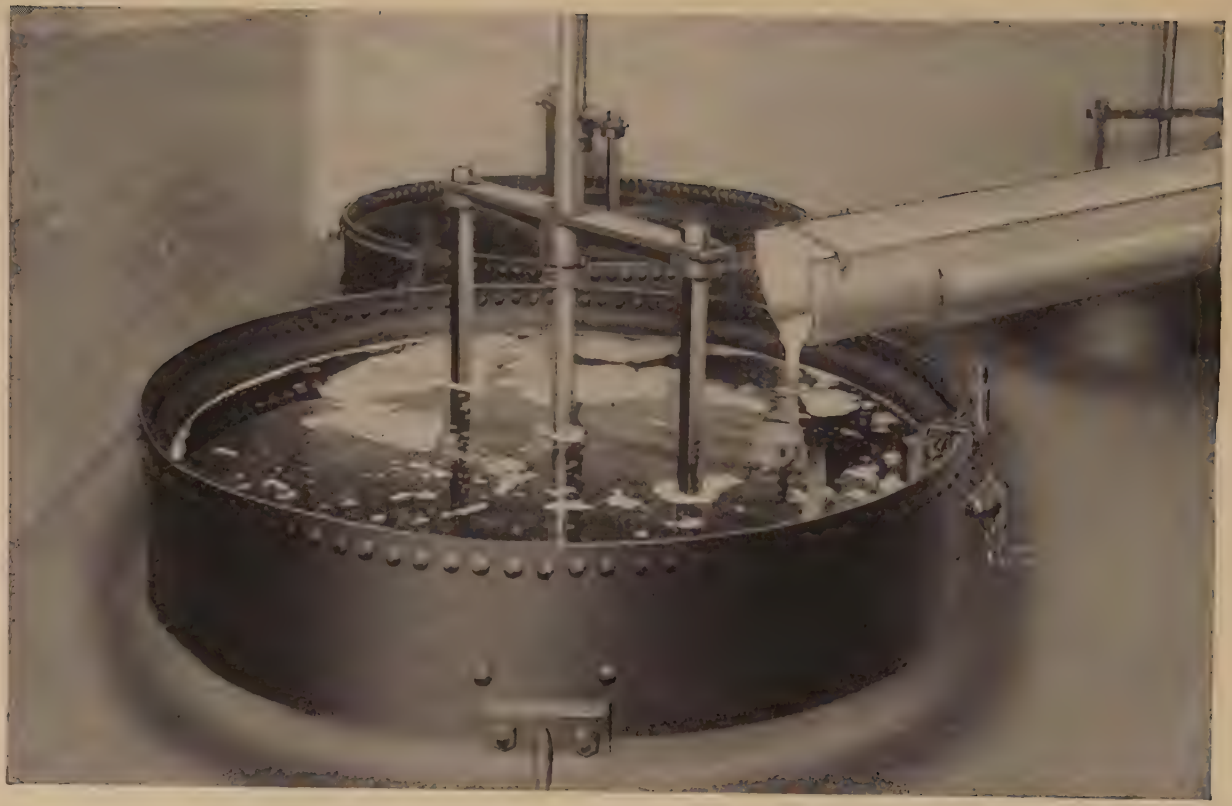
Production of lard per hog varies with the cuts being sent to the lard tanks and with the weight of hogs being slaughtered. For example, if the lard market warrants the tanking of back fat, the yields of lard per hog are greater than if the back fat is sold as such.

Kettle-Rendered Lard

One of the very earliest methods used in the cooking of fat was by rendering it in an open kettle over a fire. The quality of such lard depended largely upon the fat which was selected for rendering, the length of time that was allowed to elapse between the slaughtering and the rendering, and the temperature of the fat while being rendered, as well as the intensity of the fire and the manner in which the contents of the kettle were stirred. Another factor of importance was the disposition of the rendered fats. The lard was usually strained to eliminate cracklings, and, if properly handled, dry, and clean, possessed good keeping qualities. It was frequently handled in a careless manner, however, and in such cases would become rancid or sour within a comparatively short time. Even the best of such lard had a grayish-brown cast and slightly scorched flavor.

The early, small slaughterer, who had steam under pressure, introduced the steam-jacketed kettle for rendering. This was a great improvement over the open-fire method. Originally, this steam-jacketed kettle was made either square or round, the sides and bottom being steam-jacketed, and the fat cut up into small pieces and dumped into the kettle. Steam was then turned into the jacket and the fat was melted and cooked. It was frequently the custom to use a priming charge of lard that had already been rendered, in order to assist the fat to float and come into contact with the jacket.

Later, mechanical agitators were introduced. For convenience, the steam-jacketed kettles were made cylindrical, and the fat was hashed through a meat hasher, with a steam jacket for use when cold fats were being hashed. This form of processing is still common when handling the more easily rendered parts of the animal, such as leaf fat and back fat. From the killing or cutting



LARD IN PROCESS OF BEING KETTLE-RENDERED

floor, the clean fat is delivered as quickly as possible, and is hashed into the kettle with agitators running. Steam is applied to the jacket of the kettle at the same time that the hashing is started, and the moisture in the material is driven off in a cloud of steam. The agitation is continued until there is no further steam coming from the contents of the kettle, and the light-brown dry cracklings float upon the top of the kettle. This operation requires about three hours, depending upon the quality of fat, the size of the kettle, and the steam pressure used. The steam pressure is then cut off, and the agitation stopped.

From this point forward, two methods are employed. By one method, as soon as the cooking of the lard has been finished, the entire contents of the kettle are dumped into an iron receiver. This receiver is fitted with perforated strainers to strain out the cracklings, the lard running through and into a storage tank placed beneath, which is shallow, to give increased straining surface, and of a capacity equal to the contents of the rendering vessel. The storage tank is usually below the straining receiver, and the lard is pumped into it from the latter. The lard going into the storage tank from the receiver passes through two or more thicknesses of cheesecloth, or is pumped through a small filter press. It is then absolutely clear, and, after remaining long enough to cool, it can be drawn into packages.

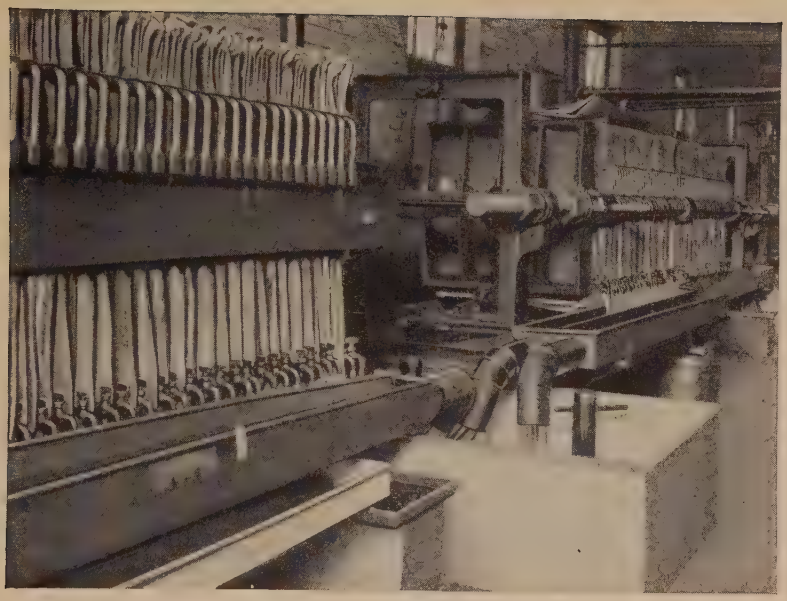
When the second method is followed, lard is allowed to settle thoroughly in the rendering kettle. This settling is assisted by the sprinkling of a small quantity of salt upon the surface of the lard. The lard is then siphoned off through an overhead siphon pipe into a receiving tank below. As it runs into the receiving tank it passes through sheets of heavy drilling which filter out all of the fine scraps remaining in the lard. The keeping quality of the lard depends to a great extent upon how thoroughly all this fine scrap is removed. Cracklings left after the lard has been removed are dumped into a strainer box beneath the rendering kettle and are allowed to drain until comparatively free from lard.

The cracklings from both of the foregoing methods are then put through a press to remove the excess lard. These presses are

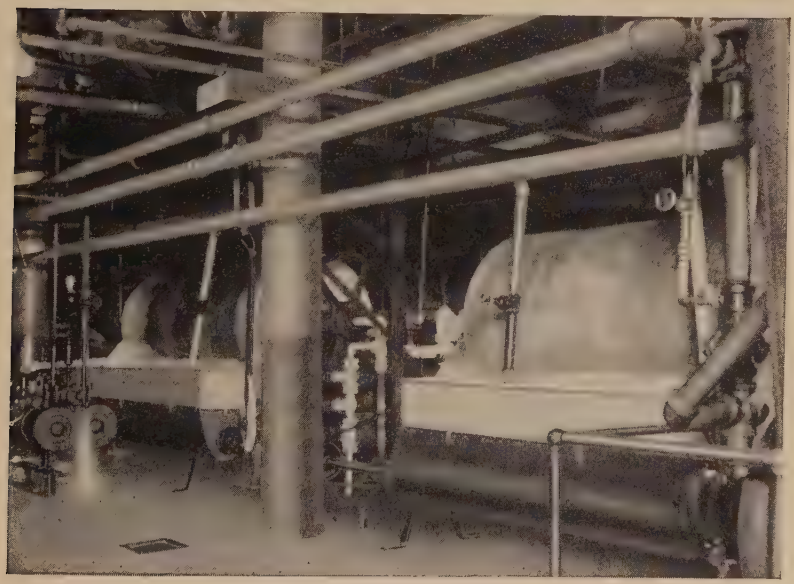
of two types: one, a continuous screw press, and the other a curb press. Lard removed by these presses is filtered through a bed of cracklings in the next run, though some operators run this lard through a filter press in order to remove the scraps. The pressed cracklings are employed in the manufacture of chicken feed. A number of renderers make all of their lard by the open-kettle method in the manner described, using killing fats, cutting fats, also sweet pickle trimmings, and grinding up the less easily rendered part of the fat, bone, etc., by means of a swing hammer mill.

On the average, the yield of leaf fats when rendered in this manner is approximately $91\frac{1}{2}$–$93\frac{1}{2}$ per cent, and back fats, 84–87 per cent. From other parts of the animal the yields vary in accordance with the material used, ranging from 65 per cent up. Greater yields can be obtained from leaf lard by freezing it before rendering in the open kettle. This involves more handling, but the expense of handling is more than offset, in the opinion of some operators, by the increased yields. Leaf lard, if to be frozen, is first hung flat upon sticks or angle iron, placed upon racks in a cooler, and, after a preliminary chilling, is taken from the sticks and placed in the freezers. Upon removal from the freezer it is run through cutting machines which slice the leaf lard into narrow strips, which are sent to the hashers.

In some localities there is a trade which demands a rather dark, high-flavored lard, similar to the country-rendered lard placed upon the market before the growth of the present lard refineries and the introduction of refined lard. This trade, however, will not pay the price for the strictly kettle-rendered lard, such as is now made from leaf and back fats. Some packers meet this demand by recooking the cracklings obtained from the manufacture of kettle-rendered lard with their production of prime steam lard. This recooking gives the crackling flavor to the steam lard, and at the same time darkens it slightly. The lard is then freed from the cracklings by straining in a similar manner as in the case of the kettle-rendered lard. Such lard is known by various names, as "butcher's lard" or "country lard." It has a pleasing flavor and very good keeping qualities.



LARD OIL GOING THROUGH A FILTER PRESS



LARD CHILL ROLL IN OPERATION

With the continual increase in size and complexity of production and distribution methods, the open-kettle rendering system became inadequate, and there was introduced the pressure, or "wet" method for manufacturing prime steam lard. Today prime steam lard amounts to almost 80 per cent of the pure lard manufactured in the United States, since it is the resulting product of the rendering of fat from the entire hog, except from the head, lungs, liver, heart, and other internal organs. For the most part, however, prime steam lard is made from fatty tissue trimmed from hams, bacon, shoulders, etc. (cutting fat), and from miscellaneous pieces of fatty tissue from the killing floor (killing fat).

Prime Steam Lard[1]

For the production of prime steam lard, vertical tanks or cylinders made of steel are generally used. Since these tanks are subjected to considerable corrosion, particularly around the rivet-heads and joints, causing high maintenance costs for rendering tanks, they would become unsafe to operate and would have to be removed and replaced unless a heavy material were employed. The depth of a rendering tank is usually a little more than twice the diameter, and an average tank has a diameter of 6 feet, 6 inches, and a depth of 14 feet, with a cone 30 inches in depth. The head of the tank is dished and is provided with a manhole for charging the material. Attached to the neck of the tank, above the floor, is a galvanized iron apron, fitted snugly to the neck and extending beyond the edge of the opening in the floor. This sheds the water away from the tank to the floor, and prevents corrosion.

Considerable loss results from the operation of rendering tanks without some insulation to conserve the heat. Furthermore, this loss of heat causes a great deal of discomfort to employees in the rendering department, especially in hot weather. Therefore, rendering tanks are generally covered with at least 2 inches of insu-

[1] The author is greatly indebted to the Committee on Practical Research of the Institute of American Meat Packers for permission to use technical data from the revised edition of *Readings in Packing-House Practice*, Part III, "Manufacturing Operations," prepared by the Committee for the Institute of Meat Packing, 1927.

lating material. After the insulating material is applied, care is taken to prevent damage by water coming from the floors above.

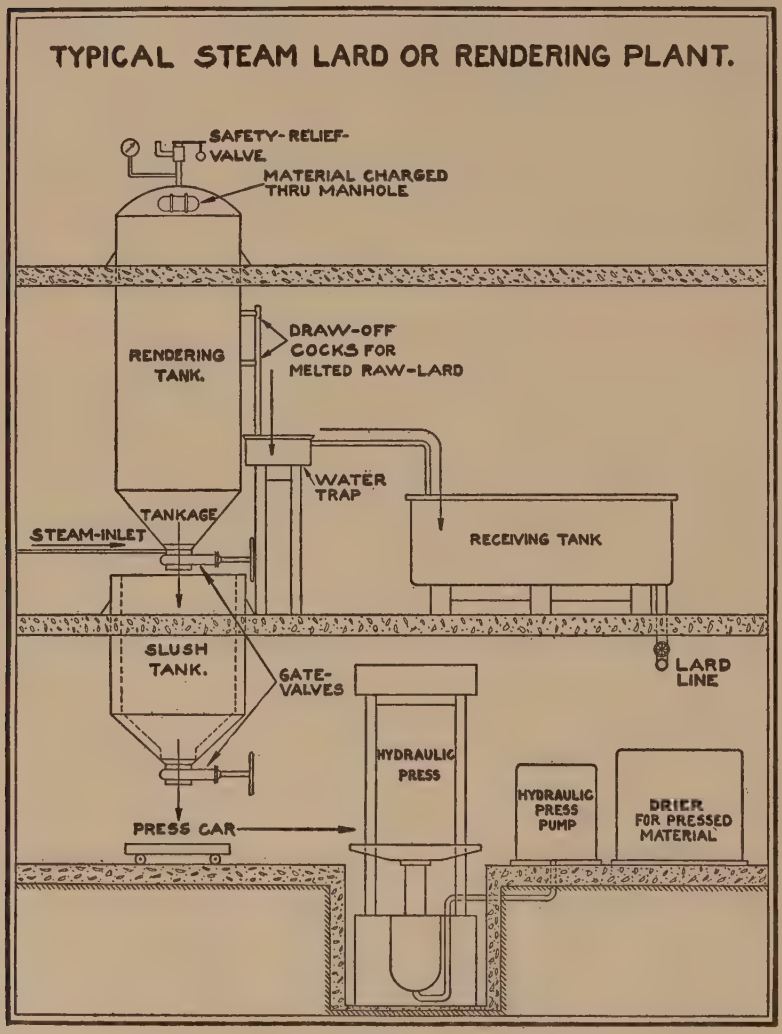


FIG. 12

The bottom of the rendering tank is cone-shaped, the cone being half as deep as the diameter, to the bottom of which a quick

opening valve, 10 or 12 inches in diameter, is attached. A 2-inch slush cock is placed about 6–10 inches above the bottom of the cone, and 1½-inch steam inlets are provided on both sides of the bottom. The tank is fitted with two draw-off cocks on the side of the shell, the lower one placed a little over one-third of the distance above the base of the shell, and the other about 8–10 inches higher and 6–8 inches to the left. The location of the draw-off cocks is such that when the operation of cooking is finished, they are at approximately the right place on the side of the tank for drawing off all of the lard without any mixture of tank water.

The steam line to the rendering tank from the boiler is provided with a steam reducing valve to reduce the boiler pressure to 40 pounds, at which pressure the rendering operation is performed. Furthermore, a safety relief valve is placed between the reducing valve and the rendering tank to provide for a relief of pressure if the reducing valve fails to operate. A control valve is placed in this steam line for turning on and off the steam as required for rendering. Between this valve and the rendering tank a check valve is located, which serves to prevent the contents of the rendering tank from backing into the steam line, in case the steam pressure drops and the higher pressure in the rendering tank reverses the flow in the steam line.

The inlet provided in the flanged bottom for the steam is also connected with a water line, which is supplied with either hot or cold water, and is used for raising the level of the lard in the tank if it is necessary. In some plants, water that has been used for cooking edible products in the rendering tank is used in place of either hot or cold fresh water. This avoids the dilution of the cooking water with clear water, which later has to be re-evaporated, with a consequent extra use of steam.

The head of the tank is connected with a 2-inch line which carries off the vapors of cooking through a common header to a condenser. In this line between the common header and the tank, a 2-inch valve is placed to prevent the steam from any one tank that is being rendered from backing, by mistake, into a tank being loaded but not headed up for cooking. The condenser, to which

the 2-inch header leads, condenses the steam. The resulting condensate, together with the non-condensible gases, is discharged to the sewer. Non-condensible vapors are sometimes piped from the condenser to a point beneath the fire grates in the boiler room, and these gases, after passing through the fire, are consumed, thus being rendered odorless. The 2-inch line leading from the rendering tank is also provided with a 2-inch gate valve, a 2-inch relief valve, a small pet cock, and in some cases with a pressure gauge. The 2-inch gate valve is to control the escape of steam and vapors from the rendering tank during the cooking operation, and is left wide open at the start of the cooking. Later on, it is partly closed and the exhaust is tested through the pet cock.

Before the rendering operation begins, the tanks are thoroughly washed out in order to keep them absolutely clean and sweet. A few heads, or any other kind of bones, are then placed in the bottom of the tank, for the purpose of preventing the raw material from packing close to the bottom valve and the slush cocks, and later causing difficulty in the removal of the contents or of the tank water. Next, the tank is filled a third full of cold water, and some operators keep additional cold water running in and out all during the operation of loading. The running in and out of cold water during the operation of loading serves to keep the material cool and floats the various particles separately, thus obviating any danger from packing, which prevents the heat of cooking from reaching the fat quickly enough.

The raw materials to be rendered are dumped into the tank to within 2 feet of its top, when the fat is covered with water, and steam is admitted. When the water, by the admission of steam, is in a boiling condition, it is removed through the slush cock at the bottom of the tank, an operation which is termed "parboiling," whose purpose is to remove any blood or adhering foreign matter from the material which has been tanked. An advantage of this method, according to some experts, is that parboiling helps to produce a much better flavor in lard. After the contents of the tank have been parboiled, sufficient water is added again to fill the cone of the rendering tank. This is done to prevent the dry

steam used in cooking from impinging directly upon the fat. The head is then placed on the top of the rendering tank, and the valve in the 2-inch exhaust line opened wide. Steam is turned into the tank through the connection in the cone. Meanwhile, the exhaust is examined from time to time, and as soon as the air and gases in the rendering tank have been expelled, and blue steam begins to come through the pet cock, the 2-inch valve is nearly closed. For if it is wide open, there is a tendency, as the cooking operation proceeds, for the steam entering the bottom of the tank to blow through the material and cause a discharge of a mixture of steam, water, and lard through the 2-inch relief line. The partially open valve allows the escape of enough steam to create a circulation in the tank and to aid complete cooking.

The operator in charge examines the sides of the tank occasionally to see that no cold spots occur, for such spots cause sour lard. They are indicated by a sweating of the surface of the tank, and if any are found, the steam is shut off and as much excess water as possible drawn off through the slush cock. This action serves to loosen the material in the rendering tank and to allow the steam and hot water to come into contact with the cold material causing the cold spots.

When the tank is overfilled with material, or contains excess water, foaming is likely to occur. This can be remedied by shutting off the steam and allowing the contents of the tank to settle for a short time. The condensed cooking water which thus settles to the bottom is then drawn off carefully, and cooking is resumed. Approximately eight hours is the usual time of rendering, but this varies with the size of the tank and the nature of the raw material. For example, bones require more time than straight fat material; materials such as skimmings and neutral bottoms require the least cooking.

After the cooking operation is completed, one-third of the contents of the tank is water, but remains so only as long as there is 40 pounds of pressure applied. If the pressure is suddenly removed, this water has a tendency to burst into steam. If this occurs, a violent mixture of the contents of the tank results, and

the water and lard become emulsified, a condition which is very hard to break, and which causes the lard produced to be under first-class quality. Consequently, every precaution is taken to remove the pressure of the steam so gradually that the danger of emulsification is avoided. The amount of pressure upon the rendering tank at the completion of the rendering operation can be estimated by opening the pet cock and noting the violence of the exhaust from the tank. A small quantity of salt is sprinkled upon the surface of the lard in the rendering tank to insure complete separation of water and lard. Before being removed, the lard is allowed to settle for two or three hours.

If the operation of rendering has been carried on successfully, it will have separated the contents of the tank into three layers of product, viz., bone and fiber in the bottom, water in the middle, and lard on top. If the loading has been properly done, the line of demarcation between the lard and the tank water is approximately where the 2-inch draw-off cocks are located. If for any reason this line of demarcation is above or below the draw-off cocks, the right levels can be obtained either by the addition of water to the rendering tank or by the removal of cooking water from it. If it is necessary to add water to the tank in order to raise the level of the lard, it is added slowly, for if added too rapidly, or if the water is considerably colder than that in the rendering tanks, convection currents may be set up which will cause an undesirable mixture of the tankage, water, and lard in the rendering tank. After the line of demarcation between cooking water and lard is brought to the level of the lower draw-off cock, the lard is removed from the upper draw-off cock. Thus the danger of removal of any cooking water with the lard is greatly lessened.

The lard removed from the rendering tank through the draw-off cocks is run to a separator tank, which has two partitions, thus giving an underflow and an overflow current to the lard as it passes through. This process is accomplished by placing the first partition in the line of flow flush with the top of the separator tank and at least 1 foot above the bottom, and the second partition flush with the bottom of the separator and 3 or 4 inches below the

top of the tank. The outlet of the tank is then placed at a level slightly lower than the top of the second partition. By this arrangement the separator serves to remove cooking water which may remain in the lard, for any moisture left in lard is very detrimental to its quality. Indeed, moisture should never be present in excess of $\frac{1}{4}$ of 1 per cent, because if there is also nitrogenous matter, the water, combining with it, ferments and causes a sour lard.

From the separator the lard is run into a receiver, a steel tank about 30 inches deep, provided with a steam-jacketed bottom or steam coils placed beneath it. There is a cock in the bottom for drawing off any settlings. On the side of the tank, about 2 inches above the base, is another cock through which the lard is removed. The 2 inches of lard thus left prevent the removal of any cooking water or settlings which have been carried through by mistake or carelessness. As a further precaution, before any lard is taken from the receiver, all cooking water or settlings present are drawn off. This tank is completely emptied every day for washing and drying, and the bottoms are removed and placed in the next regular tank charge for recooking. But in spite of all these precautions, the lard in the receiver will contain a small proportion (about $\frac{1}{4}$ of 1 per cent) of moisture, in suspension, which must be removed by the application of a slow and moderate heat to the lard in the receiver through the medium of the jacket or coil. Finally, the drying operation is completed when a sample of lard removed from the tank in a glass bottle remains clear and unclouded, even though cooled to a temperature of about 100° F. After being thoroughly dried, the lard is ready to be pumped to the refinery. However, if intended to be barrelled for prime steam lard, it should first be cooled to a temperature of about 100° F. to prevent drying and shrinkage of the barrels, with subsequent leakage and loss.

Dry Rendering

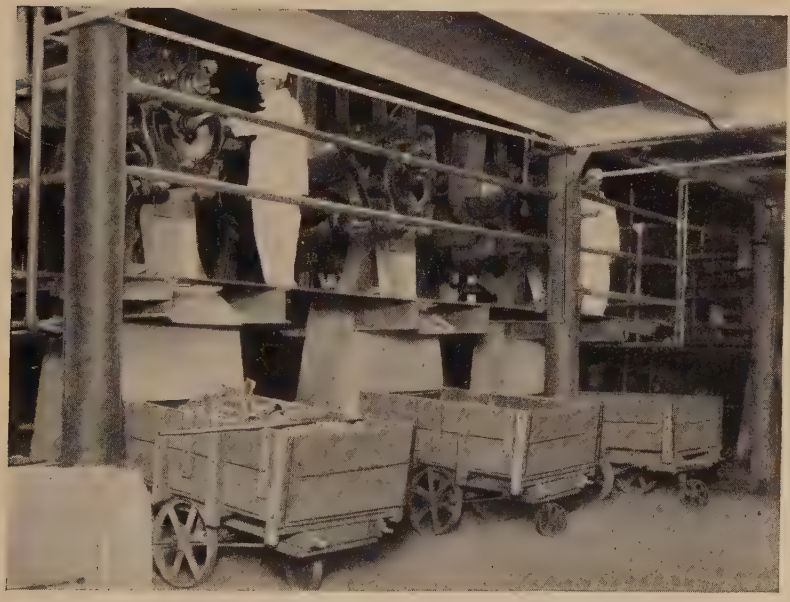
At the present time a new system called "dry rendering" is being advocated for handling such raw material as is now steam rendered. In this system the soft materials are hashed, the bony materials are crushed, and both are placed in a horizontal steam-

jacketed cooking tank. This is equipped with rotating arms to agitate the material while it is being cooked, and to keep the surface of the shell clean in order to aid the ready transmission of steam from the steam jacket to the material. The moisture from cooking is either expelled to the outside air through a large vent, or is drawn off by vacuum and then condensed. After the material is cooked, it is discharged into a tank containing a perforated false bottom, which retains the fiber or crackling and allows the lard to drain through. Afterward, the lard is clarified by filtering and is handled similarly to steam lard. The cracklings are completely drained and run through either an expeller or a curb press for removal of all possible lard. The resultant product from this pressing is used for chicken feed and like purposes. The lard expressed at the same time is returned to the melters and run through with a following batch.

A variation in this process involves a preliminary cooking of the material by steam pressure developed from the moisture contained in the material itself when subjected to heat. This pressure cooking softens the bone in the material being rendered, and is said to develop a better color in the product. Universal adoption of "dry rendering" has been delayed by the difficulty of obtaining, in all cases, a lard product as light in color or as bleachable as that turned out by the wet-rendering process. The trade has become accustomed to the flavor of the prime steam, or wet-rendered lard, and since dry-rendered lard has an entirely different flavor, the export and domestic trade, as well as the Chicago Board of Trade, require time for adjustment to the change. On the other hand, the by-products from dry rendering, in the form of cracklings, are more easily disposed of than either the tankage or concentrated stick made by the wet-rendering process.

Whether wet or dry rendered, after settling, the lard is run into a cooler which is about 30 inches deep and is provided with a steam-jacketed bottom, or is heated by means of coils underneath the tank. When cool, this lard is ready to be filled into tierces for Chicago Board of Trade delivery. However, if a packer maintains a lard refinery, the lard is usually pumped from the receiver after settling, and is then subjected to a process known as refining.

DRY RENDERING PROCESS



CRACKLINGS FROM RENDERING PROCESS

Lard Refining

Lard refining consists of clarifying, slightly bleaching, and drying. It is a process by which moisture and impurities are removed from rendered lard, and the color is partially removed. Formerly, caustic soda, borax, lime, alum, soda crystals, and bicarbonate of soda, of which caustic soda was the most popular, were in use by some refiners of lard. Under an old method now long out of use, refining meant agitating the soda in solution with the melted lard in sufficient quantities to neutralize the fatty acid in the lard and to throw down excessive coloring matter. However, this process has now been superseded by the use of certain decolorizing agents, e.g., fuller's earth, which bleach and clarify the lard, by being agitated with it in a refining or bleaching tank, and then being removed by a filter press.

Bleaching tanks vary in size, but a satisfactory tank for a medium-sized plant is one 8 feet in diameter by 8 feet deep, with a cone bottom, and is either steam jacketed for heating purposes or equipped with coils. Mixture of the decolorizing agent with the melted lard is performed by air or mechanical agitation. If air agitation is used, the air is introduced through an open end pipe extending to the bottom of the tank. On the other hand, mechanical agitation is carried out by a set of propeller blades 14 inches in diameter, placed in the base of the cone and propelled at a high speed by a vertical shaft extending to the bottom of the tank and directly connected at the top either to a motor or to a belt from a drive shaft. A circulation of the lard upward in the center and downward on the sides of the tank is created, and thus the decolorizing agent is intimately mixed with the melted lard, and at the same time the bottoms of the bleaching tanks are scoured. This cleaning of the bottom of the bleaching tank causes efficient transmission of the heat from the steam jacket to the lard. The same effect is also secured if coils instead of a steam jacket are used for heating purposes. By the mechanical agitation the maximum benefit is obtained from the decolorization agents, because all of the agent has been kept suspended in the oil during the operation. Such complete suspension is not so easily accomplished by air agitation.

In order to be bleached, lard is pumped into the bleaching kettle and heated to a temperature of 160°–180° F. It is then mixed thoroughly, either mechanically or by means of air, with a sufficient amount of the decolorizing agent. The operation of mixing is short, because if the decolorizing agent is left in contact with the lard over fifteen minutes, the flavor of the lard will be impaired. Therefore the mixture of lard and decolorizing agent is pumped as quickly as possible through a filter press, a device for removing the decolorizing agent from lard. At first the filtrate coming from the filter press is rather muddy and is returned to the bleaching kettle until it becomes perfectly clear. This recirculation places a thin coating of the bleaching agent upon the surface of the press cloths. As soon as the lard becomes perfectly clear it is diverted into another tank, called a receiving tank, and from it is pumped to the packaging room, to be run over the lard roll.

The filter press consists of a series of plates with corrugated surfaces covered with cotton ducking, which acts as the filtering medium, with the plates as a support. The plates are pressed firmly together and are constructed in such a way as to form a continuous chamber into which the mixture of lard and fuller's earth is pumped. The construction gives maximum filtering surface in a minimum of floor space. The mixture of lard and bleaching agent is forced in the press containing the cotton ducking and the lard passes into a small passage in each plate leading to a bib cock. From the bib cock the filtered lard flows into a trough, and from the trough into a receiving tank. The corrugations on the surface of the plates are for the purpose of holding the ducking from the surface of the plate, and thus providing passageway for the filtered lard to flow away from behind the ducking.

After the lard is bleached, air under pressure is blown through the press to remove any portion of lard remaining in the recesses of the plate. Steam is then blown through to remove lard retained by the earth. After this, air is again blown through the press to dry out the earth coated upon the cloths. It is necessary, in all these operations, that both air and steam be free from moisture or condensate before being blown through the press. Moisture

has a tendency to cause the earth to become sticky and to prevent the passage of any material through it. It also reduces the property of the decolorizing agent for absorbing coloring matter.

Bleaching is unavoidably accompanied with a loss of flavor and also of keeping qualities. Such loss increases with the amount of decolorizing material used and the extent of the decolorization. Therefore, a minimum amount of bleaching material necessary to produce a lard possessing a pleasing flavor and good keeping qualities, even though not snow-white in color, is employed. In the case of the use of fuller's earth, not over $\frac{3}{4}$ of 1 per cent is used, and many packers operate with the use of $\frac{1}{3}$ of 1 per cent, the lower percentage being more easily maintained by large refiners than by smaller ones. Where large quantities are being bleached, the later portions are run through the press without the addition of any decolorizing agent, and the bleaching effect is obtained from the earth already in the press. This is known as the continuous process of bleaching, as contrasted with the batch system in use by smaller plants. Where the batch system of bleaching is adopted, each refining tank of lard contains its proportion of fuller's earth, and when the total batch is run through the filter press, the bleaching tank is filled up again, the decolorizing material is added, and the operation is repeated.

Decolorizing Agents

To insure the use of the minimum amount of decolorizing agent, the color of the bleached lard is checked by the use of a tintometer and Lovibond color glasses. The use of a tintometer is essential to obtain maximum efficiency in bleaching. It has been found that even expert refiners are deceived in the color of lard and require some fixed standard with which to compare the lard as it is bleached. Such control of color may be obtained by submitting samples of lard for examination at regular intervals when the continuous method of bleaching is employed, or by examination of samples from each batch when the batch system is in use. The results of these examinations determine whether the next batch to be bleached shall have more or less bleaching agent add-

ed, the object being to have the result of the final mixture of a day's run equal in color to a standard previously selected. A preliminary examination of the color of the lard to be bleached also aids in determining the amount of earth to be used. However, heating and agitating lard in combination with a decolorizing agent tends to oxidize the lard, and is avoided as far as possible. The decolorizing agent acts as a catalyst and thus helps to induce oxidation in the lard from the air with which it comes into contact. Obviously, agitation by means of compressed air is worse than mechanical agitation, because it exposes the fat to additional oxygen.

The object of refining is to produce a mild-flavored lard, of good color and free from impurities. In judging the flavor three factors have to be considered, viz., sweetness, rancidity, and sourness. For lard is said to be sweet, rancid, or sour in flavor. "Sour" lard results from fermentation of any tank water and finely divided tankage left in the lard, and such a sour flavor can develop independently of the acid content of the lard. In brief, a lard decidedly "sour" may be low in acid content. A rancid flavor in lard may be caused by the age of the lard or by the action of the bleaching agents; and rancidity can, like sourness, develop independently of the acid content of lard. Contact with oxygen of the air aids the development of this rancidity in lard, for if there is no oxygen present, the fat never becomes rancid. Again, under certain conditions, light, heat, and moisture cause rancid lard. It is an interesting fact that certain metals, such as tin, tend to cause lard to turn rancid. Finally, it should be noted that sterilization has no effect on rancidity, for sterilized fat becomes rancid as quickly as unsterilized.

To summarize this survey of refining, various precautions must be observed if lard is to be refined successfully. These may be set down as follows: (1) Lard must be dry when bleaching material is added. (2) The minimum amount of bleaching agent must be used. (3) The color standard should not be set too high. (4) Control of color should be carefully supervised. (5) Bleaching should be carried on as rapidly as possible.

Various decolorizing and clarifying agents are used by refiners, of which diatomaceous earths, carbon blacks, and fuller's earth are the most important. Diatomaceous earths, from which Kieselguhr and similar products are made, are deposits of the minute skeletons of sea animals. These earths, when ground, give a porous, inert, cellular, and very light mineral product, weighing about 8 pounds to the cubic foot. The value of this material as a clarifying agent is due to its extremely fine porosity, by means of which liquid, when forced through its minute channels, is freed from any foreign material, due to its adherence to the walls of these channels. Diatomaceous earths have no decolorizing properties, and are merely filtering and clarifying agents. Because they have very free filtering qualities, they are sometimes mixed with other decolorizing and clarifying agents to enable more lard to be pumped through a filtering press with a given quantity of decolorizing agent. One advantage of diatomaceous earths, compared with other clarifying or decolorizing agents, is that they do not impart an undesirable flavor to the lard, and their use is not accompanied by any bad effects upon its keeping qualities.

Carbon blacks are obtained by the destructive distillation of many vegetable products, and are sometimes mixed before distillation with chemicals which are afterward leached out of the carbon, leaving countless voids in the carbon black. This adds to its absorptive qualities. Carbon blacks are seldom used alone as decolorizing or clarifying agents because such small quantities are required to produce a given color that a sufficient quantity of them is not added to the lard to coat the filter press satisfactorily. Consequently, it is very difficult to remove the carbon black from lard, when used by itself. Where dark-colored lards are to be decolorized, carbon black is very often mixed in a small proportion with fuller's earth to give it added decolorizing power.

Fuller's earth was one of the original decolorizing agents employed in bleaching lard, and in spite of many attempts to replace it by some alternative, it is still used to a greater extent than any other material. Fuller's earth, until quite recently, was obtained almost entirely from England, because the deposits of English

earth were very uniform, and its processing had been perfected. In later years deposits of very satisfactory American earth have been developed, and the method of handling it has improved to such an extent that large quantities are now used in place of English earth. The desirability of fuller's earth, or any bleaching agent, cannot be determined entirely from chemical examination, for earths of the same chemical composition may have entirely different bleaching values and mechanical properties when used in a lard refinery. The selection of fuller's earth is usually made after an actual trial has been carried out in the plant. These trials are made with a view to determining the bleaching qualities, the abrasive action, grease retention, and the free filtering qualities of the earth.

Packaging Lard

Lard, on being refined from prime steam lard and made ready for packaging, undergoes a slight shrinkage, which varies from 17/100 to ½ of 1 per cent. This variation is due to the moisture content of the prime steam lard, to the amount of fuller's earth, and to the character of the earth being used for decolorizing. The more quickly lard is consumed after being rendered, the more moisture it contains, and consequently the less the shrinkage that results after refining. Grease retention by fuller's earth, or other decolorizing agents, runs from 10 to 20 per cent, and therefore the greater the amount of decolorizing agent used in the bleaching process, the greater the loss from this cause.

After lard has been bleached and run into storage tanks it is ready to be prepared for packaging. In general, lard is shipped to customers in two forms: smooth lard or grainy lard. Smooth lard is prepared by precooling to 110° F. and then running the lard over what is known as a chilling cylinder or lard roll (opposite page). This method of quick chilling prevents any separation of lard into its constituents of oil and stearine, and enables the lard to withstand a higher temperature, without softening, than if it were slowly chilled. Where large quantities of lard are being handled, the precooling is hastened by running the lard, previous to chilling, over a water-cooled roll or through double pipe coils, water-

FILLING CANS WITH LARD

EXTRACTING OILS BY HYDRAULIC PRESS

cooled. The lard-chilling cylinder consists of a cast-iron or steel cylinder through which chilled brine is pumped, or in which ammonia is expanded directly. In plants where brine is used for a refrigerant, the supply is obtained from a tank sufficiently large to fill the roll completely and also leave enough reserve to insure uniform temperature at all times. The brine tank, if large enough, also acts as a reserve of cold and equalizes the load upon the refrigerating machine at any one time during the operation of chilling. A pump forces the brine through to a shell-type cooler, through the roll, and then back to the storage tank. Proper results from the roll depend upon uniform brine temperature and uniform circulation. Checks upon this are obtained by the installation of thermometers in the brine feed and discharge lines of the roll. Brine should enter the roll at 0° F. and leave at 10° F. A greater spread than this in temperature indicates insufficient circulation.

A feeding trough is attached to the side of the chilling cylinder, or lard roll, and below this is a scraping knife. The cylinder revolves in such a way that when the warm lard, at a temperature of about 110° F. is charged into the feeding trough, the chilled cylinder takes up a thin coating of lard. The thickness of this coating may be regulated by use of a metal bar placed close to the face of the cylinder. The cylinder revolves at such a rate that the coating of lard is completely chilled by the time one revolution has been completed. As this chilled coating encounters the scraping knife placed just below the feeding trough, the cold lard, now down to a temperature of 60°, is scraped off and drops in a solid sheet into a picker trough, which is located below the chilling cylinder. The speed of the cylinder is usually from 12 to 16 R.P.M. The capacity of any lard roll depends upon the brine circulation, the speed of the roll, and the temperature of the lard spread upon the roll. A variation in any one of these changes the capacity of the roll.

The consistency of the lard finally delivered to the package depends upon the temperature at which the lard is fed into the picker trough, and the speed of the pickers. If the lard drops into the picker box in too liquid a condition, it never thoroughly sets

in the package, and if the lard in the picker box is beaten up too much by the picker arms, through excessive speed or through remaining in the box for too long a time, the consistency of the lard is permanently ruined.

While in most cases after chilling the lard is delivered directly to the package from the roll, in some installations the use of an agitator is employed. This agitator consists of a cylindrical tank, water-jacketed and equipped with slow-moving agitator arms. The lard is pumped from the roll into this agitator and is held there until wanted for packaging.

Before the advent of refrigeration all lard was filled into packages while hot. As a consequence the chilling of the lard was so slow that the stearine and oil separated and the lard became grainy. A certain type of trade still demands this grainy lard, and some wholesalers, jobbers, and retailers do not believe the product is pure lard unless it comes to them in a grainy form. This grainy lard is made by two different methods: (1) The lard is filled into the packages hot and allowed to grain in the package, or (2) it is pumped hot into a tank and allowed to grain in the tank, later being put in the packages in a semiliquid condition. A graining tank is provided with an agitator which is operated while the packages are being filled, in order to maintain a uniform mixture of stearine and oil. If this agitator were not employed, the oil would separate from the stearine, the stearine settling to the bottom and the oil rising to the top. Therefore some of the packages would contain all of the stearine, and others all of the oil, and only a few would contain a proper mixture of both. The agitator method of filling grainy lard is generally employed when wooden packages are to be filled. The process of filling hot lard into wooden packages always has a tendency to shrink the packages and cause them to leak.

When lard is filled in tins while hot and is allowed to grain in the tins, a temperature of 130° is employed; and after the filling is completed the tins are stored in a temperature of 40°. It is customary to pile the tins without the covers until the lard has set, for the placing of the covers upon the tins retards the chilling

process. Those packing companies which make a practice of filling lard hot into packages use a flexible steel hose for this purpose. By this means lard may be filled into the packages in the position the packages occupy while the lard is chilling. This saves a great deal of labor and waste. Chilling of the hot lard when filled into small packages is sometimes aided by the use of fans which keep a steady flow of cold air across the surface of the tins containing the lard.

Lard is shipped in several forms, viz., tins, woodenware kegs, or pails, or cooperage, i.e., barrels or half-barrels. The tins used are generally flared and provided with friction top covers. The flaring is to provide for shipment of empty tins in a nested condition, so that they will not occupy as much space as if handled separately.

Lard tubs or pails are carefully inspected for wormholes or knotholes, and are thoroughly silicated before using. The silicate fills the pores of the wood and prevents the seepage of the lard through the wood, and also avoids loss by soakage. Tierces used for the filling of lard are of a tight and well-coopered type, and are treated with silicate in the same manner as tubs. Some lard manufacturers prefer to paraffin the inside of their lard barrels where barrels are used for cold lard, claiming that the lard, when taken from the barrel, peels away from the staves much more readily where paraffin is used.

It is customary to coat the outside surface of barrels with gloss oil, cheap paint, or varnish, which prevents dirt from being worked into the pores of the wood when the barrel is being rolled around in transportation.

The filling of lard into large packages, such as tierces, barrels, half-barrels, kegs, etc., is usually done at "catch weight." The container is weighed, the tare weight is marked on the package, which is then filled with lard to the utmost capacity, after which it is reweighed and branded with both the gross and net weight. When filled into tubs, 50-lb. cans, export boxes, etc., lard is usually weighed upon platform scales, the package being weighed and the exact net amount of lard added. For the filling of small cans or

cartons, small, even-balanced scales are used. As these cartons or cans are all of exactly the same weight, a constant tare may be used. This tare is the amount of lard plus the weight of the package itself, thus giving a uniform gross weight to balance against the filled package.

In filling small packages, the weight is checked carefully and the scales examined every day. For when thousands of packages are filled daily, a very small mistake on each package may mean the difference between profit and loss. Recently machines have been invented for automatic weighing of packages, both large and small (with the exception of tierces, barrels, etc.). These automatic machines measure lard out into cylinders, and discharge the contents into packages. Exact accuracy, as well as a very considerable saving in labor, is obtained by the use of these machines. Finally, lard tins are carefully packed into crates for shipment, the tins being fitted into the crates as tightly as possible to allow no leeway for jostling during shipment.

Storage of Lard

Prior to shipment, lard is stored in a temperature of 50°–60° F. Lard shipment may be made over a long distance without icing cars, and indeed it is not considered necessary to ice shipments except in very hot weather and in the southern states. At times of excess production it is customary to store lard for use when consumption exceeds production. In most instances packers store the lard as prime steam, because they have found that the keeping qualities of prime steam lard are better than those of refined lard. However, there are a few packers who make a practice of storing refined lard in packages, but in such cases care is taken to ship the lard within three months from production. The advantage of storing an excess production of lard in the form of refined lard is the saving of the labor expense of two handlings, viz., when lard is placed in storage, and later when taken out for refining.

Prime steam lard is stored in tierces or in tanks. Specifications for the handling of it apply equally well in either form of storage, but such specifications are rather more important in

the case of lard stored in tanks. For the results are usually more serious if the specifications are not rigidly observed in the latter case, due to the danger of spoiling a large quantity of product.

In lard storage the following are essential conditions to be observed: (1) Lard must be free from moisture and impurities. (2) It must be of prime flavor and color. (3) It must be at a proper temperature when being pumped into the storage tanks or filled into tierces. (4) Storage tanks or tierces must be clean. (5) Lard must be protected from contact with moisture during the period of storage. (6) It must be stored under proper temperature conditions. (7) It must not be reheated repeatedly. (8) Storage tanks should be of convenient size and proper design, and in a favorable location.

The most important point regarding the storage of lard, which cannot be too strongly emphasized, is that the lard must be free from moisture and impurities. Lard designed for storage is taken from a rendering tank that has been carefully and successfully settled. Furthermore, after the lard has been run off from the rendering tank it is settled and carefully dried in a receiver.

Some operators do not consider settling and slow drying the most desirable method for the removal of moisture and fine fiber from lard, but pump the lard through filters coated with diatomaceous earth other than fuller's earth. Finally, when dry-rendered lard is being placed in storage it is thoroughly and completely freed from fine cracklings, either by settling, or, if necessary, by filtering. To insure care in these operations, inspection and examination of a sample of each batch of lard to be sent to storage is made by someone in authority at the time of storing, who is made responsible for results. Lard is also inspected at regular intervals by the same person as long as the lard is held in storage. At these inspections it is determined whether the lard is still free from moisture, and whether its flavor is satisfactory. For no lard should be stored other than lard prime in color and flavor. This point is particularly important when storage is in tanks. The addition of a single batch of off-quality lard is liable to spoil the contents of an entire storage tank.

To prevent separation of oil and stearine, some packers chill the lard over a roll when being pumped to storage tanks. An alternative method is to allow the daily amount of lard pumped into storage to chill before the succeeding day's pumping is poured on top of it. Such a procedure avoids excessive separation of stearine, and does not entail an admixture of air with the chilled lard, such as occurs when lard is chilled over a roll. However, this is not necessary when lard is being stored in tierces, for in the case of tierces, lard is filled at a temperature of about 100° F. At this temperature the lard runs freely into the barrel, and is not hot enough to cause the barrel to shrink.

When lard is stored in tanks, inspection is made of the steam coils before the tanks are filled and after they are empty, to see that the coils are tight. Otherwise, condensed steam will be introduced into the lard during the heating process. When lard is stored in tierces, care is taken that temperatures and atmospheric conditions are such that the tierce will not shrink and cause a loss of lard from leakage. Storage tanks are usually placed so that they are protected from the direct rays of the sun in the summer, and from extreme cold in the winter. If they are built in exposed places, heating and removal of the contents is both expensive and difficult, and reheating of lard darkens its color and impairs its bleaching qualities. It is best to design storage tanks so that only the amount of lard desired to be removed from the tanks will be heated, the remainder in the tank being maintained in a chilled condition.

Wherever possible it is desirable that the size of the tank be such that it can be completely filled and emptied at one pumping. Though the size of the tank may vary to suit the particular requirements, small units are safer.

In deciding between storage in tierces or storage in tanks, an operator bears in mind the following points:

Storage in tierces requires labor for filling the tierces, labor for taking the tierces to and from the storage place, labor for coopering, labor for dumping, and a considerable amount of proper storage in which to place the tierces. The storage in tierces is also ac-

companied by a loss from shrinkage due to lard soaking into the tierces, and through leaking.

The advantages of storing in tierces are: better flavor and color of lard, and less danger from large quantities of lard being spoiled through careless handling.

The advantages of storing in tanks are: less labor for handling, and less shrinkage. The disadvantages are: more care required in the storing of the lard and a poorer quality of lard taken from storage.

It must be noted that no matter how carefully or by what manner lard is stored, the flavor of the lard taken from storage is never as desirable as that of fresh lard, and it is necessary, when using up storage lard, to mix with it a certain proportion of fresh lard in order to impart a desirable flavor.

Export Lard

Where lard is exported to foreign countries it has to conform to trade demands, both in the matter of packaging and quality, which in some cases are quite different from those of the domestic markets. Lard destined for England and Europe must be white in color, firm in body, and is usually packed in boxes divided into two compartments and lined with parchment to prevent leakage. Among other foreign markets, Cuba demands a lard very highly flavored, this flavor being termed "chicharron." It seems that a prime steam lard containing a large proportion of killing lard meets the Cuban demand for this particular flavor. The tierces used for Cuban lard shipments have to be exceptionally heavy in order to withstand the extreme climatic conditions. For this reason some packers ship their lard in bulk to Cuba and package it after arrival. On account of their tropical climate, lard shipped to some of the South American countries must be exceptionally hard in consistency in order to withstand the heat. This condition is sometimes obtained by the mixture of a considerable percentage of oleo-stearine. Furthermore, lard shipped to South America is often transported some distance inland by pack horses and burros; consequently the packages must be exceptionally strong.

Tankwater and Stick

The watery layer left in the tank after lard rendering is known as tankwater, and contains gelatin and various nitrogenous extractives. It is drawn off and evaporated in triple-effect evaporators (at which stage, on account of its sticky condition, it is known as "stick") and is mixed with stock feed. The solid residue of tankage left in the tank is dried and sold either as animal feed or fertilizer, depending upon the grade and quality.

Neutral Lard

Some of the first grades of selected leaf lard are rendered at as cool a temperature as possible, without cooking. This produces neutral lard, a much more delicate and exacting product than the ordinary lard of commerce. Neutral lard is manufactured for the margarine trade, and the object of this process of rendering is to obtain a fat, neutral in flavor and odor, so that it will not interfere with the milk flavor introduced by adding ripened milk, the butter flavor from oleo oils or from pure butter which may be added in the process of manufacture. Practically all neutral lard used in the United States is manufactured from leaf fat. This fat is the hardest of the lard-producing fats, possessing a titer of 41°–42° C. In physical characteristics it resembles butter fat, which explains why neutral lard is manufactured almost exclusively for use in margarine. This is known as No. 1 neutral lard, but there is a demand in some foreign countries for neutral lard from back fat, which is known as No. 2 neutral lard. This neutral lard is neutral in flavor, and is used as a basis for margarine or butterine. It is also used in baking. Both bakers and confectioners are finding its use desirable in replacing butter, for they get equally as good or better results by using a small percentage of butter with a considerable amount of nuetral lard, since the butter flavor is all that they desire. The neutral lard possesses no flavor of its own, is a superior shortening since it lacks the curdy sediment characteristic of butter, and has fine keeping qualities. The other grades of lard would not do because their flavor is so distinctive that it would be imparted instead of butter flavor.

To obtain freedom from flavor, the fat is separated from the natural tissues in the leaf or back fat by melting. On account of the necessity of melting the fat free from the tissues instead of boiling the moisture from the raw material, as in the manufacture of kettle-rendered lards, it is necessary to use only such raw materials as contain a very high percentage of fat. It is impossible to melt fat free from other raw materials obtained from the hog, which are high in their proportion of tissue. For this reason leaf lard, which is very nearly 98 per cent lard, and back fat, which runs nearly 90 per cent lard, are the only raw materials from which it is feasible to attempt to melt out the fat for a neutral lard.

The leaf lard is taken from the hog carcass upon the killing floor and is sent immediately to a cooler, where it is spread flat over sticks or metal angle irons supported upon racks, and is chilled for 24 hours at a temperature of 24° F. This chilling also aids in the later hashing of the leaf lard to a consistency at which there is an easy separation of fat and tissue. After the leaf lard is thoroughly chilled it is run through a hasher and dropped by gravity into a water-jacketed melting kettle. This type of kettle is used instead of a steam-jacketed kettle in order to maintain a closer control upon the temperature of the product being melted. A steam line leads into this water jacket, and is used for raising the temperature of the water to the proper point. Close control of the temperature of melting is essential in obtaining a properly flavored product, for if the temperature runs too high, the product is bound to be highly flavored. The kettle is also provided with an agitator which runs at a very slow speed, about twelve revolutions per minute, since higher agitation would tend to emulsify the product.

As soon as the leaf lard begins to drop into the melting kettle, steam is turned into the jacket of the kettle, and the temperature of the product in the kettle is raised to about 126° F., at which temperature the material is maintained until there is a complete separation of fiber and melted lard. The separation is aided by sprinkling very fine salt from time to time upon the surface of the lard. In all, about 5 lb. of fine salt are used for every 5,000 lb. of

raw fats. As soon as the clear lard shows signs of separation from the tissue, the agitator is stopped and raised completely out of the kettle. The material in the kettle is allowed to stand for a short time, and then the clear lard is siphoned away to a tank beneath the melting kettle.

As it is thus siphoned off, the lard is run through a strainer consisting of two or three thicknesses of cheesecloth, which takes out any fine fiber that may have floated through the siphon pipe. As the process is carried on, the siphon pipe is gradually lowered in the kettle until all the clear oil has been removed. It is during this operation that salt is scattered upon the surface of the kettle to aid in the complete settling of moisture and fiber away from the clear lard. After all the clear lard has been removed, the remainder of the material in the tank, which consists of fiber and moisture and is known as "neutral bottoms," is pumped to the lard-rendering department, where the rest of the lard contained in the fiber is removed by steam rendering and is mixed with the production of prime steam lard.

The clear neutral lard which has been siphoned away from the melting kettle is settled, and if there are any bottoms they are drawn off. The lard is then allowed to cool to a temperature of about 118° F., and is barrelled, the barrels being left in a temperature of about 75° F., with the bungs out. After 24 hours, however, these bungs are replaced and the barrels are moved to a temperature of 50° F., at which temperature they are allowed to grain for at least three days. The neutral lard made from leaf fat is known as No. 1 neutral.

When market conditions for neutral lard are favorable for the packer, it is sometimes financially profitable to manufacture back fat into neutral lard. This is known as No. 2 neutral, and sells at a slightly lower price than No. 1 neutral, and is processed very similarly to the leaf lard. The back fat is hashed in a similar manner to the leaf lard, but on account of its physical structure, it has to be melted at a higher temperature, about 132° F., and therefore gives a product somewhat higher in flavor than the neutral made from leaf lard. Neutral lard, whether made from leaf or

back fat, if properly handled and finally chilled in the barrels has a very large grain, a bluish-white color, and a mild, pleasing odor and taste. Its natural consistency is such as to enable its use to replace the portions of butter formerly used in the original oleomargarine formulas.

The residue from the rendering process is known as cracklings. Lard cracklings may be coarsely ground for chicken feed, or can be finely ground and made into flour. Lard-crackling flour is a rich food product containing 6–7 per cent of lard, and 84–86 per cent of protein. A palatable bread may be made by mixing one pound of lard-crackling flour with six pounds of wheat flour. Another product, lard oil, used for edible purposes, is pressed from "prime steam" lard. This lard oil is used by manufacturers of pharmaceutical products.

Lard Oil

The fluid expressed from prime steam lard in which the separation of lard stearine also takes place is known as lard oil. It has a soft, pleasant taste, and being almost free from odor, forms a good edible oil. It consists in the main of olein, with a little linolein and a small proportion of glycerides of solid fatty acids, chiefly palmitic acid. Lard oil is a high-class burning oil, and is used for illuminating purposes by lighthouses, on ships, in miners' lamps, and in headlights of locomotives, on account of the penetrating effect upon fogs of the flame produced by burning it. For these places it is of special value because it is free from the danger of explosion and will not thicken at low temperatures. The highest grade of edible lard oil is used in margarine manufacture. Before the day of high-speed oils, inedible lard oil was used extensively as a lubricant by textile manufacturers and machine shops producing small parts for typewriters, sewing machines, automobiles, etc.

At present lard oil is principally used as a lubricant for thread-cutting machines, for which purpose it has no equal, both in efficiency and economy. Any saving on initial cost by buying inferior oils containing mineral products is more than balanced by the

expensive wear and tear of dies and machines due to improper or insufficient lubrication. Breaks and accidents, which are frequently laid to alleged defects in steel or iron, should rightfully be charged against cheap oils of inferior quality. Lard oil tends to cling to any tool and the metal being worked on, thus leaving a substantial film of oil between the two for the purpose of lubricating. Lard oil penetrates the metal, soaks into it, and fills the pores. When the cutting tooth enters the metal it is still lubricated. This feature explains why smooth cutting is so readily possible with lard oil.

Another advantage is its much higher flash point, which makes lard oil a lubricant under temperatures at which other oils are driven off in the form of smoke. Such temperatures are commonly reached in high-speed work and automatic screw machines. Some users also believe that lard oil serves to temper steel.

Lard stearine, left after edible lard oil has been pressed out, is used in a limited way to stiffen lard from "soft and oily" hogs, produced chiefly in the South on feeds such as peanuts and soy beans. Limited amounts also are purchased by candy manufacturers. Most lard stearine is used for mixing with vegetable oils in producing lard compounds. Inedible lard stearine serves in the manufacture of cup greases and similar lubricants.

The grades of lard described thus far are the only ones suitable for edible purposes. Lower grades, obtained from the whole carcass of condemned animals, are used only for non-edible purposes.

Economics of Lard Production and Consumption[1]

The growing use of vegetable oils has led many authorities to declare that the consumption of lard is diminishing. At first sight it seems logical that the lower-priced vegetable product, which, after all, can be produced in much greater volume than animal fats, should supplant the latter in the human dietary. However, there is very little in the statistics to warrant this assumption.

[1] Monthly Letter to Animal Husbandmen (June, 1927) of Armour's Livestock Bureau.

Lard is eaten for its flavor, or the flavor it imparts to the products in which it is used. In general, advertising campaigns have served to increase the consumption of vegetable fats, and therefore of total fats, rather than to decrease the consumption of lard. Table VIII, showing per capita consumption, comes from the reports of the Bureau of Animal Industry.

TABLE VIII

Year	Per Capita Consumption (Pounds)	Five-Year Average (Pounds)
1907	12.1	
1908	12.9	
1909	11.5	11.8
1910	11.4	
1911	11.3	
1912	11.2	
1913	11.4	
1914	12.2	12.3
1915	12.9	
1916	13.6	
1917	11.7	
1918	13.3	
1919	12.3	12.4
1920	13.3	
1921	11.3	
1922	14.2	
1923	15.3	
1924	15.4	14.3
1925	13.2	
1926	13.5	

Figure 13 shows the seasonal consumption of lard. As might be expected, it is lightest in the summer months and heaviest in the fall and winter months. The graph suggests that there are two sources of lard which normally go into consumption: The first is that produced in federal inspected packing plants, while the second is produced on the farm or by small butchers and local packers. The trend of consumption of lard produced outside of federal inspection was determined by the apparent rate of slaughter of hogs outside of federal inspection as suggested by the estimates of the United States Bureau of Animal Industry, some earlier estimates of the Bureau of Agricultural Economics, and the census rec-

ords of farm slaughter. It was estimated that, on the average, the hogs slaughtered under federal inspection would yield about 13.5 per cent of lard (prime steam lard plus leaf), and that other hogs would yield about 15.5 per cent. It is of interest that the greatest consumption of lard produced under federal inspection falls in the months from July to December.

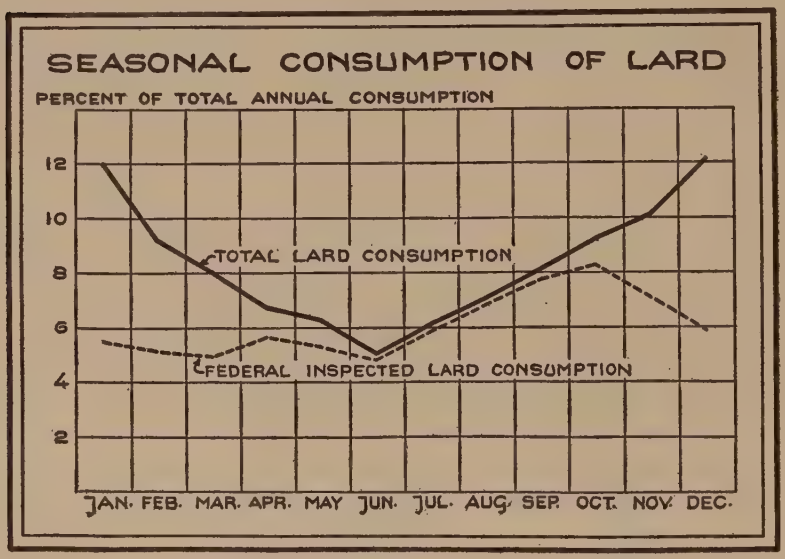


FIG. 13

One of the prime factors in the lard business in creating a sense of security in its manufacture is the relative price of hogs and lard. If hog prices are high in proportion to lard, there is only a small margin on which the lard manufacturer can operate, and his risks with regard to profit and loss consequently increase. On the other hand, if lard is selling at several cents per pound above live hogs, and if fat cuts are in demand, the situation is much more healthy from the viewpoint of the lard processor.

Heavy corn crops may or may not affect this relationship. Frequently they increase production of lard no more than other classes of fresh pork and provisions, so that lard does not suffer in

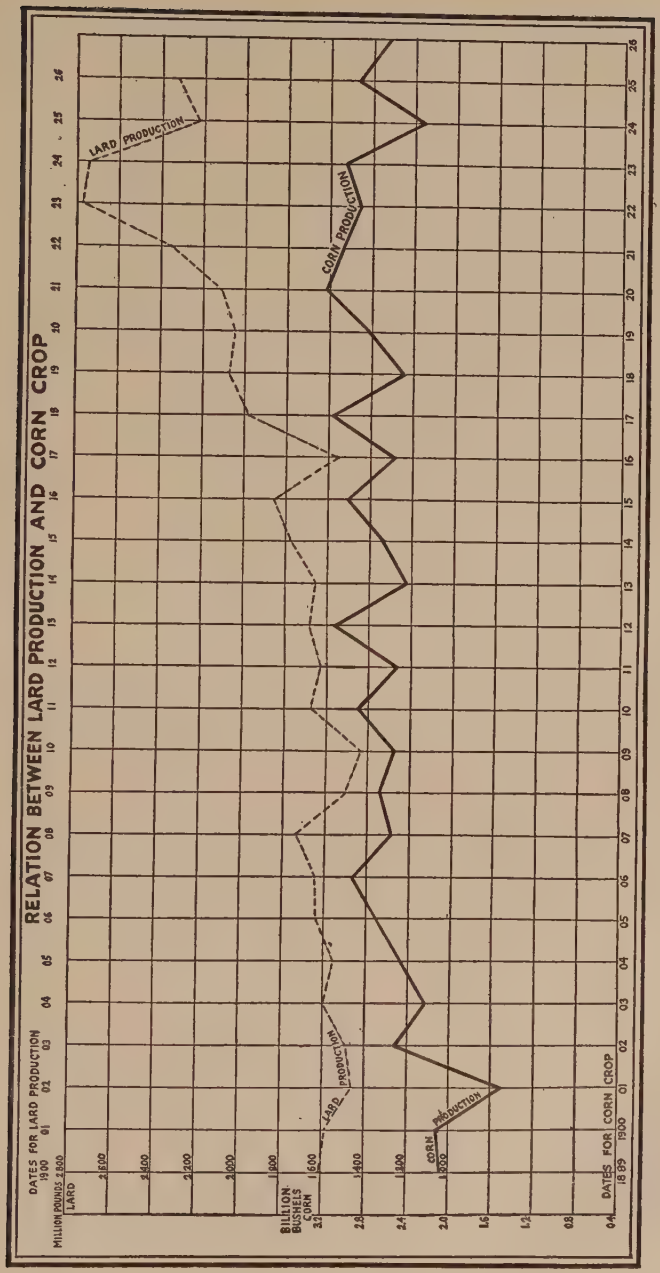

RELATION BETWEEN LARD PRODUCTION AND CORN CROP
DATES FOR LARD PRODUCTION
1900 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
MILLION POUNDS
LARD
2,800
2,600
2,400
2,200
2,000
1,800
1,600
1,400
1,200
1,000
LARD PRODUCTION
BILLION BUSHELS
CORN
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
CORN PRODUCTION
DATES FOR CORN CROP
1889 1900 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

FIG. 14

comparison. This was the case, for example, in 1923 and 1924, when the largest slaughter of hogs known in the United States was recorded, yet lard stayed in favorable price relations to other hog products, and especially to live hogs.

The relation between the corn crop and total lard production is rather intimate. Figure 14 compares the corn crops from 1899 to the present with lard production of the subsequent year. In general, it will be seen that the two curves conform to each other

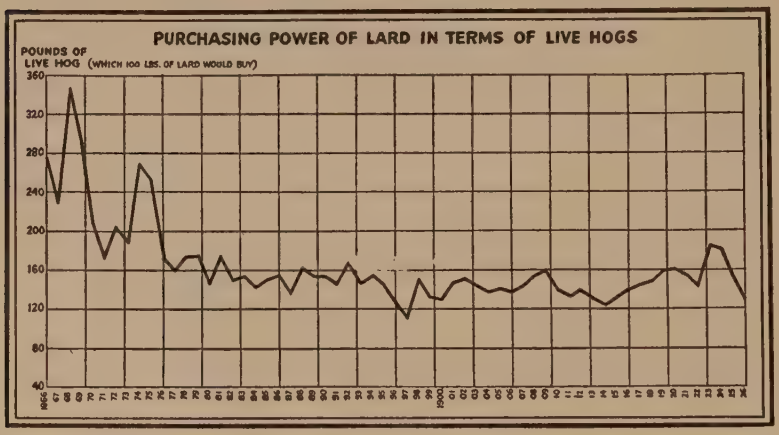


FIG. 15

rather closely, although for such a period as the 1902 corn crop and the 1903 lard yield, the directions of the two curves are divergent for the years immediately following. The explanation is simple, since the carry-over from the unusual increase in corn had effect into later years. The same explanation will cover the divergences of the war period.

Figure 15 and Table IX present the relations between hog and lard prices since 1867. Figure 15 is calculated to show how much live weight of hogs a hundred pounds of lard will buy. In general, it will be seen that lard was relatively high priced following the Civil War and during the World War and post-war period, with the exception of the 1922 minor depression. Following 1924,

however, the purchasing power of lard in terms of hogs reduced rapidly, and it was undoubtedly a factor in causing the concern which hog producers and some lard manufacturers felt in regard to lard prices.

Table IX presents the converse of Figure 15, in that it shows how much lard a hundredweight of hogs will buy. The columns

TABLE IX

POUNDS OF LARD ONE HUNDREDWEIGHT HOG WOULD PURCHASE

Year	Pounds Lard	Year	Pounds Lard	Year	Pounds Lard
1866	36.22	1886	64.56	1906	72.84
1867	43.20	1887	73.65	1907	69.87
1868	28.80	1888	61.76	1908	65.44
1869	34.06	1889	64.66	1909	63.09
1870	48.16	1890	64.89	1910	72.65
1871	58.00	1891	68.69	1911	75.62
1872	48.88	1892	60.02	1912	72.66
1873	52.90	1893	68.75	1913	77.10
1874	37.14	1894	65.16	1914	81.05
1875	39.18	1895	68.91	1915	76.26
1876	58.12	1896	78.66	1916	72.67
1877	62.50	1897	88.94	1917	69.42
1878	57.17	1898	67.19	1918	67.66
1879	56.66	1899	75.98	1919	62.85
1880	68.31	1900	77.45	1920	62.52
1881	57.21	1901	68.20	1921	64.42
1882	66.06	1902	66.24	1922	70.54
1883	64.38	1903	69.77	1923	54.31
1884	69.86	1904	73.15	1924	55.36
1885	66.56	1905	71.62	1925	65.98
				1926	77.89

are so arranged that direct twenty- and forty-year comparisons can be made.

From the standpoint of the lard manufacturer, Figure 16 indicates that we returned in 1926 to lard-hog ratios which existed before the war. Lard was a relatively profitable product, especially during 1923 and 1924, and one must go back to 1875 to find a more favorable ratio than existed during the two years mentioned.

The monthly changes in volume of storage are indicated in Figure 17. It will be observed from this chart that there is a greater seasonal volume of storage in the latter part of the summer dur-

ing the five-year period. It is interesting, further, that for the year 1926 the peak of lard storage lagged about one month behind the average for the preceding five-year period. Whether this indicates a tendency to carry the consumption of lard into a later season of the year is questionable, although fluctuations in the rate of export could equally well affect the shape of the curve.

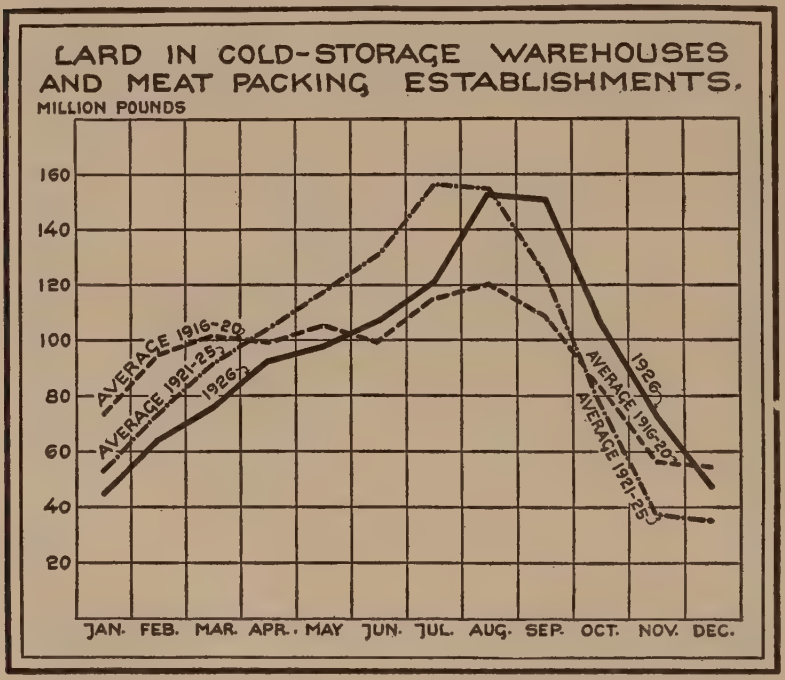


FIG. 16

Some authorities insist that storage-lard stocks influence the monthly prices of lard. Figure 17 compares the monthly storage figures prepared by the Bureau of Agricultural Economics with the monthly price averages which it reports. The simple relationship just referred to does not seem to exist, however; probably because of the cyclical nature of lard production. Since the war the rise in storage during the first two-thirds of the packing year,

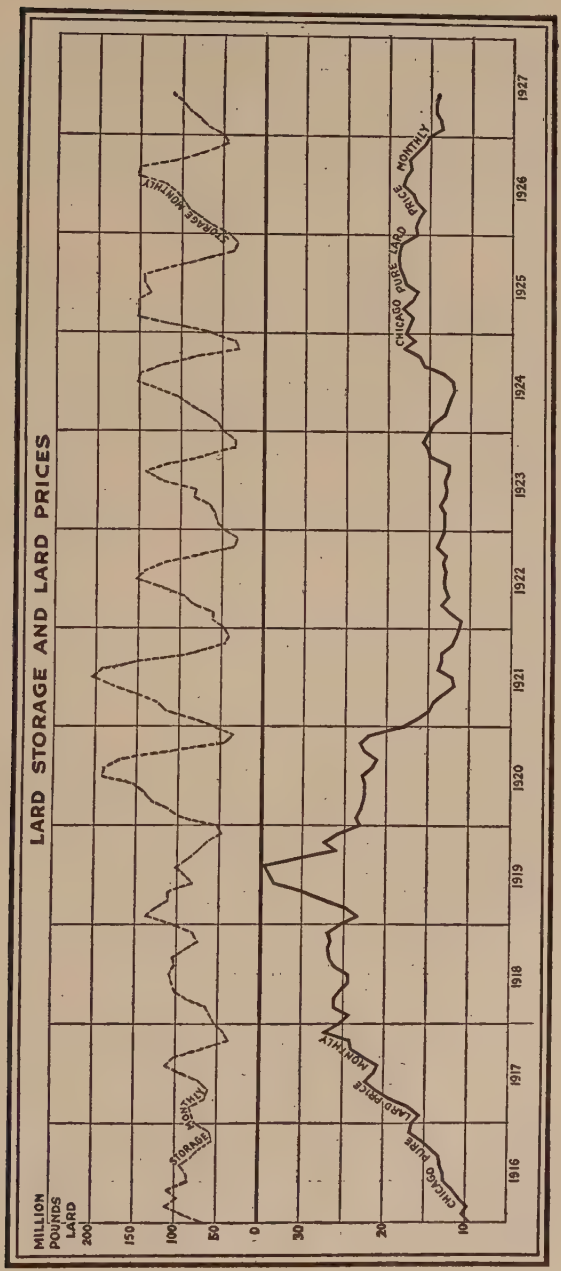

LARD STORAGE AND LARD PRICES
MILLION POUNDS LARD
200
150
100
50
0
30
20
10
STORAGE MONTHLY
CHICAGO PURE LARD PRICE MONTHLY
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927

FIG. 17

and the drop during the remaining third, has been quite regular. No such trend exists in prices, indicating that storage operates as a stabilizer and is an index of fluctuations in the supply-demand quotient. In fact, the slight monthly variations in price, outside of the long-time swings, are probably more closely related to factors operating in competitive industries.

Lard Exports

For more than a century and a quarter, the United States has been the principal country of surplus lard production, and the chief contributor to international trade in this commodity. The foundation of this commerce has been the great production of corn and other quick-fattening feeds, which are available in greater volume in our country than elsewhere. The trend of lard exports since 1900 is shown in Figure 10, with a comparison of exports of vegetable oils. The general picture presented by the lard curve suggests that, previous to the war, we were tending toward domestic equilibrium in the production and consumption of lard. At least the trend was downward from 1901 to 1917. Since that time the trend has been just as definitely upward, despite the drop since 1923.

Such lard movement, however, is not necessarily an indication of healthy conditions in the lard trade. Since the war the domestic market has provided the best outlet for the packing industry. Increased exports of lard are, therefore, as frequently a sign of lessened strength in the domestic situation as of increased strength in the foreign situation. Practically no lard is sold abroad on order. The general custom of the trade is to consign it to foreign representatives or agents, or perhaps to provision brokers, with no certainty as to the price that will ultimately be secured. The lard exporter is in exactly the same position as the livestock producer. Both ship on the basis of the apparent price level, or the prospective trend of the market, but take whatever price they may secure at the time of arrival of their shipments. The only significant difference between the two is the distance the products

are moved, and the greater risk of the exporter in this respect is partially offset by the greater stability of his commodity.

Previous to the war, Liverpool prices tended to average one to two cents above Chicago prices. During the war the margin broadened, and differences of as much as ten cents were occasionally reached. In April, 1921, the British Food Ministry ceased its

TABLE X

Year	Lard Exports (in Million Pounds)	Five-Year Average
1907	594	
1908	587	
1909	462	527
1910	382	
1911	610	
1912	558	
1913	581	
1914	465	512
1915	494	
1916	463	
1917	388	
1918	559	
1919	789	656
1920	643	
1921	903	
1922	799	
1923	1,075	
1924	986	862
1925	719	
1926	733	

control of lard, and since that time Chicago and Liverpool monthly averages have almost exactly duplicated each other. This, of course, leaves no margin to cover cost of transportation and export.

During the last twenty years the volume of lard exports has varied materially. The exports of lard form the largest single export item derived from farm animals, and American lard is a dominant factor in the world's market. In general, lard exports were heavier preceding the war than they were during the war period, due to the loss of the central European market; but since the war they have been still greater (see Table X).

Great Britain and Germany have always been the chief markets for our lard. They have been followed closely by the Netherlands and the West Indian countries, especially Cuba. Table XI shows something of the history of exports to the ten leading countries with regard to the amount of our lard which they take.

A more interesting measure of the relative importance of these countries is presented in Table XII in which the exports to each

TABLE XI

UNITED STATES EXPORTS OF LARD
(IN THOUSANDS OF POUNDS)

	1910–14 (Average)	1918	1921	1924	1925	1926	1927 (4 Months)
To:							
Canada	10,182	2,479	12,706	11,455	10,595	12,590	3,932
Mexico	7,001	15,452	43,458	39,633	46,529	45,378	13,327
Cuba	41,379	46,008	72,311	93,945	76,973	79,655	26,855
Great Britain	168,972	309,987	231,846	237,383	214,772	224,927	78,748
France	12,090	35,842	40,102	23,619	4,447	3,988	3,010
Italy	4,656	1,145	11,725	63,135	28,507	5,900	3,164
Netherlands	36,502	.....	76,965	66,150	39,944	49,365	16,231
Belgium	17,076	116,784	51,565	32,556	16,680	11,795	5,012
Germany	142,312	.....	278,045	308,541	193,004	199,533	56,620
Denmark	2,481	75	9,506	7,159	4,013	3,677	935
Total 10 Countries	442,651	527,772	828,229	883,576	632,464	636,808	207,834
Miscellaneous	76,349	31,228	74,771	102,423	86,536	96,192	.....
Total exports	519,000	559,000	903,000	986,000	719,000	733,000	.....

of the ten countries are measured on a percentage basis. Roughly speaking, it will be seen that Britain takes about 30 per cent of our lard, as also does Germany.

Superficially this may seem a favorable status, since it would indicate a favorable financial balance for us, but this is not necessarily the correct interpretation. If the importation and substitution of vegetable oils were depriving lard of certain profitable outlets that were formerly available, and if the lard denied these channels because of a price handicap would have to be consigned abroad, there would undoubtedly be a severe penalty enforced on the hog producer and lard processor.

To date, however, there seems little ground for this opinion.

It is true that the general trend of lard exports since the war has been upward, but it is also true that domestic consumption of lard has been increasing. It was pointed out that for five years ending 1911, per capita lard consumption was 11.8 lb.; for the five years ending 1916, it was 12.3 lb.; for the half-decade ending 1921, 12.4 lb.; and for the last five years, 14.3 lb. These figures certainly do not indicate that lard is being replaced by competitive substitutes, but supplement other data in the field of lard compound,

TABLE XII

UNITED STATES EXPORTS OF LARD TO TEN LEADING EXPORTING COUNTRIES
(IN PERCENTAGE OF TOTAL EXPORTS)

	1910–14 (Average)	1918	1921	1924	1925	1926
Canada	1.96	.44	1.41	1.16	1.47	1.72
Mexico	1.35	2.76	4.81	4.02	6.47	6.19
Cuba	7.97	8.23	8.00	9.52	10.70	10.87
Great Britain	32.56	55.45	25.68	24.07	29.89	30.68
France	2.33	6.41	4.44	2.39	.62	.54
Italy	.89	.21	1.30	6.41	3.96	.81
Netherlands	7.03	.....	8.52	6.71	5.14	6.73
Belgium	3.29	20.89	5.72	3.31	2.32	1.62
Germany	27.42	.....	30.79	31.29	26.84	27.22
Denmark	.48	.02	1.05	.73	.56	.50
Total 10 countries	85.28	94.41	91.72	89.61	87.97	86.88
Miscellaneous	14.72	5.59	8.28	10.39	12.03	13.12
	100.00	100.00	100.00	100.00	100.00	100.00

butter, and oleomargarine consumption to the effect that our total American fat utilization is increasing rapidly.

FUTURE TREND OF LARD

The problem which the lard industry faces is scarcely one of a substitution of cheap and inferior product. In fact, some of the most widely advertised lard substitutes are bringing prices well above the general level for lard. This has been possible because of the adoption of modern methods of processing and merchandizing, making strong appeals to the ultimate consumer.

One of the greatest difficulties in the sale of lard is the general tendency of purchasers to lump all classes of lard together, regard-

less of the method of processing or the type of raw material used. In the case of lard substitutes, they recognize the product by the brand name, but in lard the power of advertising, especially to establish distinctions in quality, has not been employed as widely.

Perhaps the principal feature in the competitive advance of lard substitutes has been the highly standardized qualities which could be specified by both buyer and seller. The original problem in lard manufacture was to create a product that would be stable in the hands of the housewife, in addition to possessing the desired flavor. The rise of commercial bakeries has created the additional problem of stability following cookery and packaging. The scientific development of baking, with its study of temperatures and of volatilization and oxidation points in the fats, has been seized upon by the manufacturer of substitutes as a possible point of entry into the new market. Some of the more progressive lard manufacturers have also taken steps to standardize their product; but in general they have depended on their branded articles to acquire a reputation.

The number of these manufacturers, however, is few. Too many have regarded lard as a by-product requiring little technique and less attention in sales promotion. It is obvious that the future competitive situation between lard and its substitutes, therefore, involves a further standardization of product, a determination of the causes of deterioration with a development of technique to overcome it, and the preparation of advertising and publicity campaigns that will give prospective purchasers the necessary chemical and physical information on lard.

CHAPTER V

FATS, OILS, AND GREASES—*Continued*

Oleo Stock, Oil, and Stearine Manufacture[1]

Unlike lard, oleo stock, from which oleo oil and stearine are made, and tallow, comes from beef fat. The structure of beef fat is very like that of hog fat. However, it has a higher melting-point, and therefore possesses greater stability because of its preponderance of saturated fatty acids. Furthermore, some valuable beef fats, e.g., neatsfoot oil, used in leather softening and waterproofing, and bone oil, are products of bone marrow and of feet.

Oleo stock is rendered from the different fats of cattle and calves, such as caul and ruffle fat, as well as the fats obtained from the large and small digestive organs, plucks, rennets, and hearts. The killing fats are transported from the slaughtering floor and are placed in water at 36°–40° F. in order to chill and wash them. The chilling is done as soon as possible after slaughtering, and the larger pieces of fat are cut up in order to cool them rapidly, for delay may destroy the best flavor of the product. If any fat has to be carried over, it is hung upon racks in a cooler at about 38° F. until processed. After washing and cooling, the fat is placed in a chilling vat containing iced or refrigerated water and kept for some 8 hours to overnight at a temperature of about 38° F. It is then removed to a truck or to a draining shelf, where it is thoroughly drained. As soon as the excess water is removed, it is fed directly to a fat hasher and hashed into a water-jacketed, bowl-shaped melting kettle which is provided with a removable mechanical agitator.

The jacket of the kettle is slightly heated and the agitator

[1] The author is greatly indebted to the Committee on Practical Research of the Institute of American Meat Packers for permission to use technical data from the revised edition of *Readings in Packing-House Practice*, Part III, "Manufacturing Operations," prepared by the Committee for the Institute of Meat Packing, 1927.

started before the fat is hashed into the kettle. When the latter is one-quarter full of fat, about 25 lb. of fine rock salt are added, and another 25 lb. each when the kettle is one-half full, three-quarters full, and completely filled. The heat is gradually increased until the temperature of the fat reaches 155° F., and the operation of melting is usually completed within two hours. After rendering, the contents of the kettle are allowed to settle for about an hour, and when thoroughly settled, the clear liquid fat may be drawn from the melting kettle into a jacketed clarifying kettle by means of a swinging suction pipe. This pipe is kept at exactly the proper height to skim the melted oil off the top of the kettle and carry it away by gravity.

The action of salt in this process coagulates the wet fiber, which, at the low temperatures, tends to remain in combination with the fat. The salt goes into solution in the water, and during the melting of the raw fat the water separates more or less completely. Dissolving of salt in the water in this way adds to the weight of the water and fiber, and thus increases the difference between the specific gravity of the fat and that of the water and fiber. Settling produces a sharp separation when salt is carefully used, thus aiding in securing the best results in skimming. The fat in the scrap or "bottoms" of the melting kettle is thoroughly skimmed off and remelted with the next batch. With careful processing, yields of oleo vary from 60–72 per cent, according to the grade of fat used. The best grades of fat yield 72 per cent of oleo stock.

The melted fat is settled for three hours in the clarifying kettle, at a temperature of about 140° F., and a few handfuls of fine salt are sprinkled over the surface of the fat. This clarifying kettle is cone-bottomed and, after thorough settling, a bucket of oil is drawn from the lower part of the kettle to determine whether the contents are free from moisture. The product is then siphoned into storage tanks or into graining trucks. Furthermore, this fat product is called oleo stock, which is the material from which the commercial articles, oleo oil and oleo stearine, are made. As practically all oleo stock is made into oleo oil and oleo stearine, it is

usually drawn directly into trucks. These "seeding" trucks are wooden or steel boxes mounted on wheels, and each hold about

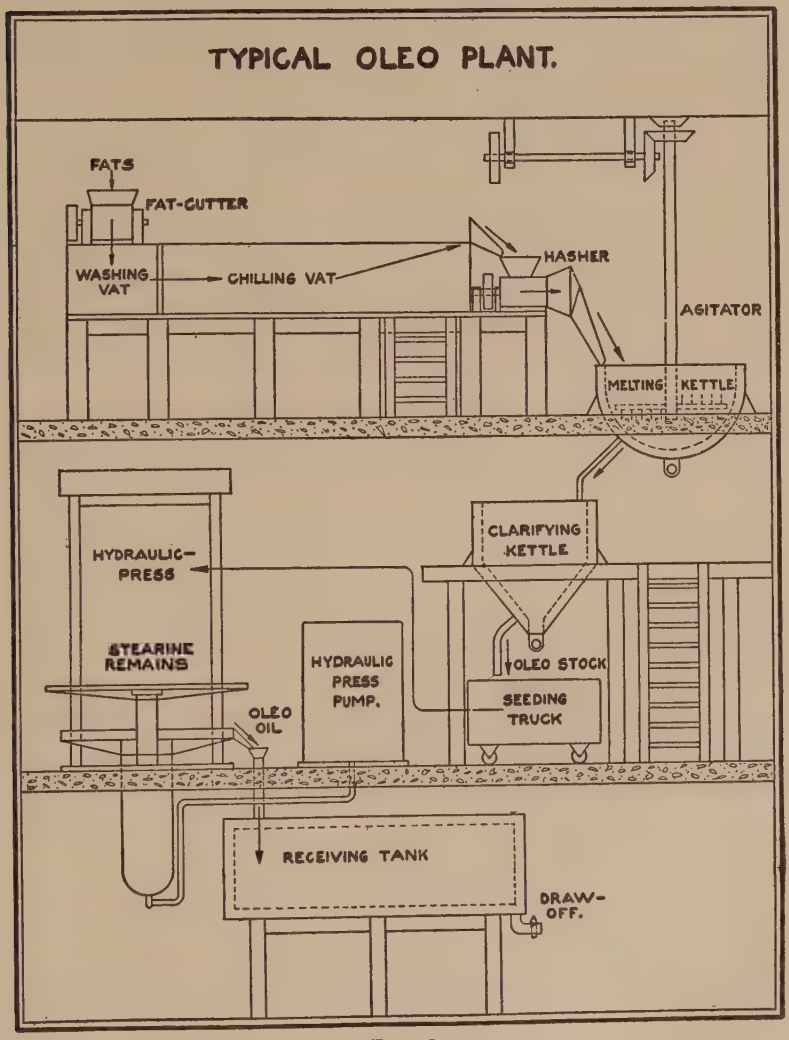


FIG. 18

800 lb. of stock. When loaded, the trucks are run into rooms maintained at a temperature of 85°–90° F.

Oleo stock, when brought to the temperature rooms just mentioned, is entirely liquid, but when held at that same temperature, the heavier fats, stearine, and palmitin crystallize and solidify, while the oil remains liquid. This temperature separation is known as "seeding" or "graining," because, in crystallizing, the stearine acquires a seedy or granular appearance.

The use of mechanical processes is needed for final and complete separation. The "grained" oleo stock is placed in bags, and pressure is applied in order to squeeze out the liquid oil and retain the solid stearine in the bag. The stock is allowed to stand in the graining trucks at a temperature of 85°–90° F. for three days, or until the stearine, or hard part of the fat, has become completely separated from the oil. When properly grained, the stock is put through a hydraulic or mechanical press in a room which is held at a temperature of about 89° F.

A standard oleo press consists of sixty plates with eight cakes to each plate. The stock is ladled out of the truck onto 6-ounce duck press cloths, spread out flat to receive the stock. These are folded over to complete a cake after the grained stock is placed upon them. When the press is loaded, hydraulic pressure is applied slowly, and the oil is allowed to run down into a jacketed iron tank, where it is heated to a temperature of about 115° F. and is then drawn into tierces. However, if the plant has an oleomargarine department, the oil may be transferred directly to that department for immediate use. When drawn into tierces, the oil is stored at a temperature of about 60° for six or seven days, in order to grain it properly for the margarine trade.

Oleo oil is bright yellow and has a hardness of about 41.5° C., measured by the titer test, which is only slightly higher than No. 1 neutral lard. The best grade of oleo oil has a sweet, bland, buttery flavor and possesses unusually good keeping quality. It is considered particularly valuable in the manufacture of margarine, on account of its high Vitamin A content, which, on the average, is the same as that of butter, and is extensively used by the baking trade.

After the press is unloaded, the stearine is shaken out of the

press cloths and packed in slack barrels of a capacity of some 530 lb., or it may be used directly in the manufacture of lard substitutes. The stearine is cooled thoroughly before packing it in barrels, for otherwise mold spots are likely to develop in the body of the stearine. If properly prepared it has a hardness of about 50° C., measured by the titer test. Oleo stearine is the hardening constituent of one type of lard substitutes. The composition of the latter is about 15 per cent stearine and 85 per cent refined cottonseed oil. Oleo stearine is also sold to confectioners who use it as a filler in certain grades of chocolate, taffies, and penny candies. Finally, it is used as a filler for leather, in the manufacture of tallow candles, etc.

Neatsfoot Stock and Oil

Besides the animal fats, animal oils are of great commercial importance. The first in interest are neatsfoot stock and oil. Pure neatsfoot stock is made from the shin bones and feet of cattle. After the feet are cut off on the killing floor, they are collected, washed with a hose in a foot washer, and trimmed. The sinews are tanked for glue, the bones are sawed, and the hoofs are removed in hot water. The bones are then cooked in an open vat with boiling water, in order to separate the fat.

For this work, about ten hours' cooking is usually required in the case of bones of the feet, and about five hours' cooking for the shin bones. The fat is then skimmed from the bones and strained through coarse heavy cloths into a steam-jacketed kettle, to which heat is applied at about 240° F. The product is then settled for about seven hours at this same temperature, when the heat is entirely cut off and the fat is allowed to stand for six hours longer. It is drawn off and is filtered through cotton flannel bags into an iron tank, from which it may be run into barrels or other packages.

This product is known as pure neatsfoot stock, to be used for the production of pure neatsfoot oil. Such stock is grained at a temperature of about 34° F. for about two weeks, and is then pressed like oleo stock, although a different type of press is used at

a temperature of 34° F., which must be maintained during the pressing. This first pressing of neatsfoot oil yields export *pure* neatsfoot oil, which is the finest grade, with a clouding point of 16°–18° F., and a free fatty acid content of about 1 per cent. Neatsfoot oil is valuable in working up fine leather, and in oiling watches and other delicate machinery. Thirty-degree neatsfoot oil is used by some silk manufacturers for spinning purposes. Can manufacturers employ it as a flux in soldering. Prime neatsfoot oil is especially adapted for knitting-mill processes, as the oil washes out very easily and does not affect the finished product. Harness makers employ No. 1 neatsfoot oil to soften leather, and linen mills use it on their spindles. The stearine from neatsfoot oil is usually regrained and pressed, and the oil extracted from this second pressing is domestic pure neatsfoot oil, with a clouding point of 26°–28° F. The stearine from the second pressing is generally used in making prime tallow.

In addition to pure neatsfoot oil, there are other grades of oil, commonly employed in working leather, which pass as neatsfoot oil. However, they are really grease oils, for they are products of the different grades of inedible greases. They have been grained and pressed in a manner somewhat like the graining and pressing of oleo stock, but the temperature regulation necessary is unlike the pressing of oleo stock, because of the different melting and hardening points of the grease oil products. Since much of the so-called "neatsfoot oil" which is marketed today is not the actual product, the real article is labeled "pure neatsfoot oil."

Edible Tallows and Greases

Beef and mutton tallow are of great commercial importance. Mutton tallow is usually richer in stearine than beef tallow, and is consequently harder. At the same time it is much more liable to rancidity, and so it cannot be used in the preparation of butter substitutes or in the manufacture of high-class toilet soap. It is therefore fortunate that the greatest quantity of tallow is produced from beef fat. The highest grade is that known as edible tallow, which is used in food preparations such as lard compound

and other lard substitutes. The free fatty acids of edible tallow do not exceed 1 per cent.

Edible tallow is manufactured in large plants from beef fat which is not considered suitable for the manufacture of oleo. Ordinarily it consists of some of the beef-cutting scrap fats, and the scrap fat from the oleo kettles is often employed. In small plants edible tallow is made from caul and ruffle fat, and the other killing and cutting fats which would ordinarily go into the manufacture of oleo in large plants. Edible tallow is sometimes made in open kettles by the same methods as "open kettle rendered lard." It is also processed from cooking up bones from the cutting room in water in open vats at a temperature of about 180° F. But edible tallow is more generally made by cooking with open steam in upright pressure tanks which are cylindrical in shape and can withstand an internal pressure of 80 lb. per square inch.

For the process of parboiling this tank is washed before being charged. Some bones are put in the tank at the beginning of the process, in order to prevent packing the material to be charged into the tank. Cold water is run in during the charging until the tank is about three-quarters full. Steam is then turned on and the material warmed up as rapidly as possible. When it is hot the steam is shut off, and almost all of the water is drawn off from the bottom, leaving just enough so that the contents of the tank will have no tendency to pack. For the cooking process itself the tank is closed up and steam turned in to capacity at 40 lb. pressure, the vent being left open. The time of rendering is eight hours, varying according to the size of the tank and the material being rendered.

When the material is cooked, steam is shut off and the pressure relieved slowly to prevent the contents from rolling, which would tend to emulsification and prevent proper separation. Two or three hours are allowed for the settling, and the tallow is then drawn off into a receiving tank which has two partitions, to provide an underflow and an overflow through it. This retains any tankwater that may have run out of the rendering tank along

with tallow. After settling, the tallow is run off to a cooler, which is a steel tank 30 inches deep provided with a steam-jacketed bottom or heated by coils placed underneath it. Mechanical separators, using the principle of the inverted cone, are employed by many packers to separate their tallow or greases from tankwater and "floaters." When cooled and settled, this tallow may be drawn into tierces or loaded into tank cars for outside delivery, or may be pumped to a refinery for use in making lard substitutes.

Inedible Fats

Inedible fats are so called because they are deemed to be contaminated. In both hog and beef fat this includes fat which is so intimately a part of the meat and bone that it is not practicable for it to be separated for use as lard, oleo, or edible tallow. In tallow it includes such parts as windpipes, end of the mid-intestines and gullets, and some of the trimmings from paunches, tripe, necks, bladders, livers, dirty sausage trimmings, catch basin and floor pickings and basin skimmings from oleo. The equipment and methods of rendering for production of inedible tallow are the same as in the making of edible tallow, though some inedible tallow is the result of cooking glue stock in open vats during the manufacture of glue.

Inedible hog fats are treated in the same way as beef fats. The cooking takes from seven to ten hours, according to the material and the size of tank. When the material is thoroughly cooked, the steam is shut off and the pet cock is opened slowly for about an hour, to prevent rolling. The manhole is then taken off and salt is scattered over the surface of the rendered fat. At this stage the tank is left open for two hours before the rendered fat is run off into coolers similar to those used in the manufacture of prime steam lard. The tankage is dumped into a slush vat, and any floaters are skimmed off and recooked with the next batch. After skimming, the steam is turned on for about ten or fifteen minutes and the tankage is agitated with a long forked pole, in order to loosen the grease held in the tankage. These skimmings are put back into the next tank to be rendered. Inedible tallow manufactured in

the way described is used to a considerable extent in the making of soap. Inedible grease is also used in soap, and, when grained and pressed similar to the method employed in obtaining oleo oil,

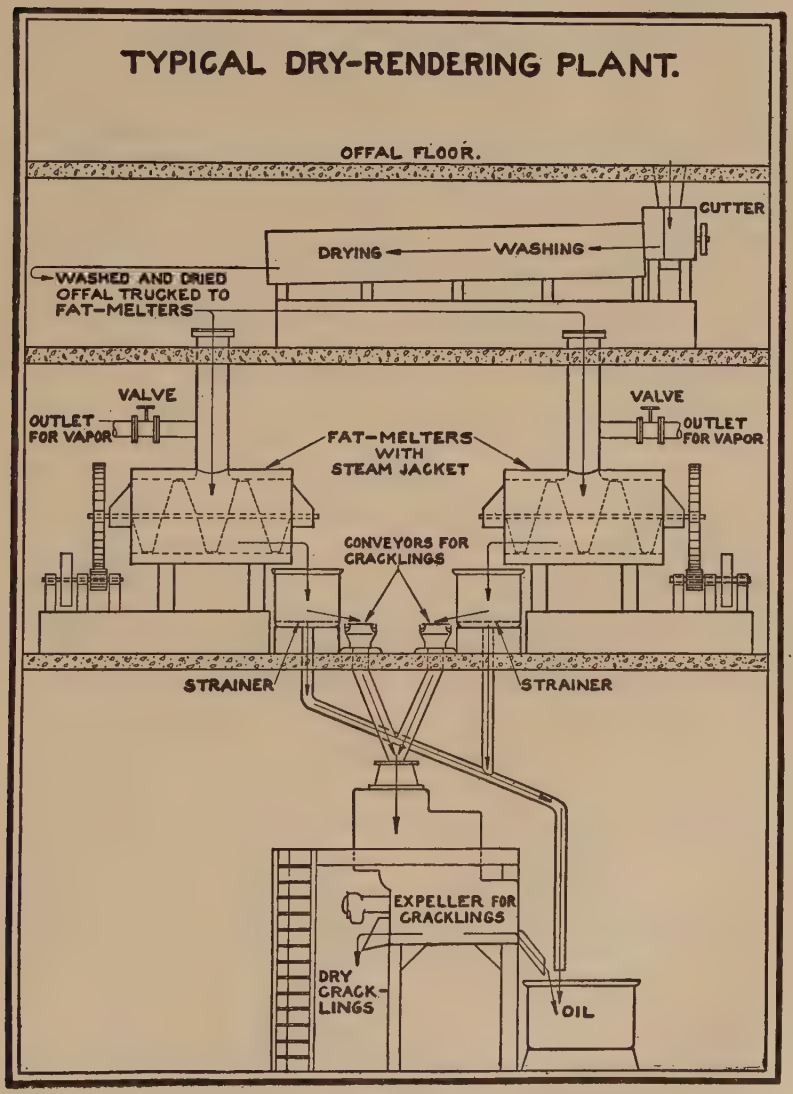


FIG. 19

produces various grades of lard oils used as lubricants for pipe cutting, etc. In rendering by this method a certain amount of decomposition results from applying steam and pressure at high temperatures.

Dry Rendering

In the past fourteen years a system called "dry rendering," already briefly referred to in connection with lard manufacture, has been introduced by manufacturers of inedible tallow and greases. This system is in its infancy and has promise of important developments. At the present time the tendency to substitute the dry-rendering process for steam rendering is for the purpose of avoiding the expense of handling tankwater and tankage, and to produce greater amounts of animal feeds. It does away entirely with the use of pressure tanks and reduces the free fatty acids, thus indicating that less decomposition takes place. Dry rendering properly includes the ordinary method of open-kettle rendering which has been in use for many years. But there is a real difference, for by dry rendering it is possible effectually to render large quantities of inedible stock. The method is a radical advance in doing away with odors around meat-packing plants, and in improving the residue, which formerly possessed a very unpleasant odor and was mostly used for fertilizer. Now this residue may be ground up and mixed into high-grade poultry and stock foods, when produced by the "dry method."

This dry rendering is carried on in a horizontal jacketed tank, with an agitator which keeps the fats stirred up, prevents the contents of the tank, or "melter," from scorching, and also permits moisture and gases to pass off more readily. Furthermore, such agitation allows the heat to penetrate thoroughly, and greatly reduces the time of operation. The gases formed are carried out by means of an open stack connected to the melter, or are drawn off by a fan, blower, or water condenser. In this manner the rendering is accomplished very quickly.

By means of the dry system there is produced a grease or tallow of low free fatty acid content, and the cracklings are very high in protein because there is no water used in the system to wash

away the protein or ammonia content of the product. This ammonia or protein is lost to some extent in the wet-rendering system, the difference in protein content between dry and wet rendering amounting as a rule to approximately 10 per cent. For example, the grease or tallow produced by the wet system often contains from 3 per cent to 35 per cent of free fatty acids, while the product from dry rendering usually runs much lower. It is possible to handle the raw material more promptly with dry-rendering equipment, moreover, thus greatly reducing the high free fatty acid content, due to organic action, which is present in material handled with wet-rendering equipment. The time required for a complete dry-rendering operation varies according to the actual cooking process, which depends on the amount of moisture in the material being rendered. In shop fats the moisture runs from 35 per cent to 40 per cent; with dead stock it is about 72 per cent moisture and requires longer to render.

In order to render raw material more efficiently, without danger of undercooking large pieces and overcooking small pieces, it is uniformly reduced to small-size pieces by crushers before the material is introduced into the melter. For the crushing operation, various types of equipment have been used, e.g., swing hammer grinders and bone crushers. One of the best type of machines consists of a drum with blades attached, which shear against stationary blades and have a cutting effect on the material fed to the machine, reducing it to a uniform fineness, to produce the best results in the melter.

Guts, pecks, paunches, etc. are thoroughly hashed and washed before going to the melter, in order to remove the contents, which would not only discolor the grease if permitted to remain during the melting operation, but would increase the amount of product in the melter without increasing the yield, thereby slowing down the operation and reducing the percentage of ammonia in the finished product. For treating such materials a combination hasher and washer is satisfactory. This machine consists of a hasher for cutting, built in combination with a perforated cylindrical washer. After being prepared, the material is fed into a melter, which has

an outer and an inner shell forming a steam jacket, with cast heads at either end and suitable agitating paddles attached to the main drive shaft. For operation, steam is turned in the space between the inner and outer shells, and the paddle shaft is revolved to keep the contents in motion during the cooking operation.

On completion of this step, the contents of the melter are discharged into a receiving tank or percolator, which consists of a rectangular tank with perforated false bottom for draining grease from the cracklings, and steam-jacketed bottom to keep the cracklings at the proper temperature. After draining in this tank, the remaining grease in the cracklings is pressed out by a hydraulic curb press, or by a screw-type continuous press, which develops a very high efficiency, operating continuously, and producing cracklings of a minimum grease content. Finally, the cracklings are usually ground in a machine grinder for use as stock and poultry feed.

To summarize, a complete plant for carrying on such dry-rendering operations as described consists of a crusher, a hasher and washer, a melter, a receiving tank, a press, and a crackling grinder, together with a storage tank for the grease produced and a pump for pumping grease to the storage tank.

Internal Pressure Dry Rendering

Under the internal pressure method of dry rendering, a melter is used similar to the melter used in straight dry rendering, except that it is built with heavy cast iron heads to withstand internal pressure in the inner shell. The operation consists of loading the melter without crushing the material, although it is generally conceded that time is saved if the product is first put through a crusher. After loading, the melter is allowed to run with the vapor line open for a short time to get rid of the first gases. It is then sealed, and the steam that develops from the moisture in the product is kept inside of the melter, producing the internal pressure from which the system takes its name. This internal pressure is usually maintained at about 40 lb., and is intended to disintegrate the meat and bones and break down the fat cells. After cooking

under internal pressure, the line from the melter is opened and the gases released into a sewer. The material is then dry cooked under a vacuum, as in straight dry rendering, to remove the remaining moisture.

The grease produced by the internal pressure method usually has a free fatty acid content about as high as that produced by straight dry rendering. The color is about the same, and the cracklings are as free from odors as the cracklings produced by straight dry-rendering. In the pressing operation the grease content of these cracklings can be reduced quite as low as the grease content in straight dry-rendered cracklings, for pressure crackling material is more easily pressed because the bone and tissue have been disintegrated.

In theory, an advantage of the internal pressure system of melting is that the steam developed from the moisture in the product, which is kept in the melter, acts as a vapor blanket to eliminate the danger of scorching and carbonization of the grease; and this steam also serves to break up the fat cells and to disintegrate the meat and bones. In actual practice the material may be scorched under this system of rendering, unless care is used to prevent it.

Pressure Vacuum Dry-Rendering

In the pressure-vacuum system the procedure is first to cook under pressure, then to release this pressure and to finish off the cooking under a vacuum, this vacuum ranging from approximately 0–20 inches. Great care must be used in releasing the pressure, or a considerable quantity of valuable produce will escape with the vapor. The reason for the use of a vacuum pump in this system is that under a vacuum the boiling-point of the product is reduced, permitting the drying to be completed in a shorter time with reduced steam pressure in the jacket and with less danger of scorching.

A comparison of the cost and result of operation between modern dry-rendering and wet-rendering equipment brings out the following conclusions, according to the advocates of the system: There are the different yields of finished products (grease and fer-

tilizer or grease and cracklings) and the value of the finished fertilizer or cracklings, and the demand for the finished product, namely, fertilizer or cracklings. A comparison of yields of the two methods shows results in favor of dry rendering. This is due to the fact that there are so many more steps in the method of wet rendering than there are in dry, and in each step there is a chance of losing some of the product. In wet rendering, even with great care and supervision, it is impossible to separate entirely the grease from the tankwater, just as it is impossible to save all the stickwater, or all the tankage. This is not true with dry rendering. Of the product sent to be dry rendered, except the water and moisture in the fat, practically 100 per cent is received at the end of the process. With the present high price of grease and cracklings, the increase in yield alone is sufficient to justify the installation of dry rendering.

In analyzing the operation cost of wet rendering from the power standpoint, certain points must be noted, viz., first, steam is required for rendering the product; second, steam is also needed for evaporating the stick, which is nearly always exhaust steam, with a small amount of high-pressure steam for operating the vacuum and stick pumps; third, power is required for operating the tankage presses; fourth, both power and steam are required for operating the fertilizer dryers; and fifth, power is needed for grinding the finished fertilizer.

Comparing the power required by these two systems, including both steam and electricity, it is stated by advocates of dry rendering that the total power required to render the green product and convert the by-products into finished fertilizer or cracklings by the dry-rendering method is approximately 30 per cent less than that required by the wet rendering.

Regarding the finished fertilizer or cracklings resulting from both methods, in the case of wet rendering, the only outlet is digester tankage. In dry rendering the cracklings can be sold either for digester tankage or poultry feed. This poultry feed commands a price premium over digester tankage, so that all the cracklings that can be marketed as poultry feed will show a profit over di-

gester tankage. Again, digester tankage made from cracklings has a higher food value than that manufactured by the wet-rendering process. In addition to these facts, the more outlets one has for finished products, the better profit is obtained.

From the standpoint of yields, finished materials, and improved working conditions and sanitation, the dry-rendering process may well be sufficiently better from a financial viewpoint, as well as from other improvements, to warrant its installation. For while there are improvements that could be made in wet rendering, such as better tankage presses, more improved methods of skimming grease, etc., even with these installed, dry rendering seems to result in a product that is easier to handle, is sold at increased profit, and can be distributed more widely.

Yet it must be noted that at the present time an important objection to "dry rendering" is that the gluey or mucilaginous material dissolved in the tankwater in open steam-pressure rendering remains in the fat and cracklings in dry rendering, and is largely pressed out of the cracklings when they are passed through the expeller or hydraulic press. Moreover, the temperature control is indefinite in many of the dry-rendering systems now in use, causing a darkening of the rendered fat.

Grades of Inedible Tallow

Soap manufacturers are ready purchasers of high-grade inedible tallow for use as stock in manufacturing the best soaps, although hog grease and mixed greases, including mutton tallow, are used also in soap making. Inedible tallow is produced in three grades, of which prime tallow is first. *Prime tallow* is produced from the choicest inedible stock. It is light in color, bleaches not to exceed 2.8 red, and 25.0 yellow, according to Lovibond test, and contains not over 2 per cent of free fatty acids. The next grade of tallow, and the most largely used, is *No. 1 grade.* This grade is rendered from the less desirable parts of the animal, containing some spoiled fats and being "off" in flavor and odor. It bleaches to about 7.0 red and 31.0 yellow, and contains not more than 10 per cent of free fatty acids. This is followed by *No.*

2 grade, which is sometimes described as brown grease, and is made from all the remaining dark-colored stock from the offal floor, catch-basin trimmings, etc. It is too dark in color to be read with the Lovibond color glasses and is high in free fatty acids.

Tallow Oils.—From tallow are derived certain oils which have considerable trade significance. Two of these are *acidless tallow oil* and *regular tallow oil*. Acidless tallow oil is pressed from prime tallow, showing a titer of about 40° C., and about 2 per cent free fatty acids. This prime tallow is put into graining trucks in liquid form, and is stored in the graining room at a temperature of 85°–90° F. for three or four days, until a good separation of the oil and stearine is effected. It is then pressed in a manner similar to the pressing of oleo stearine. Tallow oil is used by oil dealers as a basis for compounding cylinder oils. The free fatty acids in pure tallow oil are frequently neutralized by treating them with caustic soda solution, which may be done in a cylindrical cone-bottomed tank equipped with a mechanical agitator and a set of steam coils. The oil is heated to about 165° F., agitated thoroughly, and caustic soda solution, about 18° Bé., is added to neutralize the free fatty acids, with a slight excess to complete the refining. Agitation is then continued for some five minutes, and about 3 per cent of saturated salt solution is added. If necessary, additional heat may be applied, after which agitation is discontinued and the oil is allowed to settle for several hours. The clear oil is pumped away by means of a swinging suction pipe, and the "foots," or residue, goes into soap stock. The resultant oil of this process as acidless tallow oil, which is much used by mineral oil concerns for compounding. The tallow stearine left after pressing is molded into blocks and is sold as "cylinder tallow." It is a high-grade lubricant and is extensively used for packing the cylinders of heavy engines. Indeed, it is well known that animal oils make a better lubricant than mineral oils because the former possess the fundamental lubricating quality, viz., oiliness. This property of oiliness is essential in the lubrication of fast-moving machinery. Too much emphasis cannot be placed upon this feature of oiliness

or viscosity. Certainly it costs more money to replace tools than to secure a proper lubricant. In every industry one of the greatest sources of overhead expense is due to the continual grinding and replacing of cutting tools. This expense could be considerably curtailed if a proper lubricant were used. The animal oils principally employed for lubricating purposes are lard oils, rather than tallow oils, as will be seen when the discussion of them is reached.

Greases.—There is a considerable difference in the character of inedible hog fats. Some of the inedible fats, when rendered fresh, produce an article nearly as white as lard and also very low in free fatty acids. Other fats, more contaminated and containing catch-basin skimmings, floor sweepings, etc., are very dark colored and are high in free fatty acids. The important grades of greases follow: *"A" white grease* is made from the materials that would normally make lard, but for various causes are processed into white grease. It is similar to lard in appearance, although slightly darker in color, is sweet in flavor and odor, and does not exceed 2 per cent free fatty acids. *"B" white grease* has a slightly darker color and usually has an off odor and flavor, as it frequently contains sausage-room grease and low-grade sweet-pickled and dry salt trimmings. The color is lighter than 2.5 red and 20 yellow, as measured by the Lovibond color glasses, and does not exceed 3.5 per cent free fatty acids. *Yellow grease* is made from the darker-colored part of the animal, and is really an offal product. In some small establishments where all of the grease materials are cooked together, the resulting product is called yellow grease, which is dark in color, reading about 30 red and 110 yellow, and runs as high as 15 per cent free fatty acids. *Brown grease* is made from all refuse-yielding materials in the packing plant, such as all catch-basin skimmings, floor sweepings, pressed-out grease from tankage, dark-colored stock from the offal floor, etc. When these greases are grained and pressed they yield the grease oils, which are commonly known to the trade as lard oils.

Lard oils.—Prime winter-strained lard oil, which tests 1 to 2 per cent free fatty acid, is made from selected choice white grease with additional refining. *Extra winter-strained lard oil* testing

2 to 4 per cent free fatty acid is processed from an "A" white grease. Of these the prime winter strained lard oil is used for signal oil purposes, and for work of a very technical nature where a high-grade lubricant is required. Extra winter-strained lard oil is employed along practically the same lines as the prime oil, but is slightly lower in price and therefore somewhat more extensively used. *Extra lard oil* is made from "B" white grease, grained and pressed at a temperature of about 50° F., and bleached with fuller's earth. It has a cold test of about 40° F. and is a superior lubricating oil used to increase the viscosity of mineral lubricating oil and to assist in the cutting of pipe threads. It bleaches not to exceed 3.5 red and 30.0 yellow. This lard oil is often branded and sold as "extra neatsfoot oil." It is sometimes called winter-strained lard oil, because in the days before artificial refrigeration these products were manufactured only during the winter, in order to take advantage of the natural refrigeration. *"Extra No. 1," lard oil* is pressed from a high acid "B" white grease, just as "Extra" lard oil is produced from a low acid "B" white grease. It is frequently sold as an extra neatsfoot oil. *"No 1" lard oil* is made from low acid yellow greases; *"No. 2" lard oil* is made from a high acid yellow grease. These lard oils are bleached with fuller's earth and other bleaching materials in order to whiten them by the same process as in refining lard. Extra lard oil is used by brass and copper manufacturers in drawing up copper tubes, in lubricating dies, and, with petroleum oil, in signal lamps. Extra No. 1 lard oil is employed by cotton mills and carpet manufacturers for spinning. No. 1 lard oil is principally used by oil compounders in making up cutting oils. It is also utilized as a cutting oil by manufacturers of automobiles, plumbing supplies, machinery, cycles, firearms, chains, sewing machines, drills, wire and steel castings. The remaining inedible fats are employed in the preparation of such well-known products as heavy lubricating oils, illuminating oils, red oils, special leather oils, and stearic acid, the latter being used with paraffin in candle making.

Lard Substitutes[1]

The standard shortening in preparing the American dietary is lard. It has drawn the patronage of the housewife from earliest times because it has imparted a flavor to cookery which could not be imitated, and which could be rivaled for quality only by butter. The price problem, however, has always been a factor in household purchases, and a number of substitutes, less expensive as to cost, have been developed for competitive purposes. The rise in volume of consumption of substitutes has been a cause for concern to producers each time hog values declined from the peak of their cycle.

The value of lard substitutes in the domestic trade of the United States practically doubled during the two-year interval between the two censuses of manufactures, 1923 and 1925. While lard is almost exclusively a product of the packing industry, lard substitutes are produced in greatest bulk in the vegetable oil industry. Nevertheless, the packing industry is intensively involved. In 1925 the total production of lard substitutes and cooking fats in the United States was 1,128,993,000 lb., of which 622,795,000 lb. were produced in establishments primarily engaged in the manufacture of these products. The meat-packing establishments produced 450,922,000 lb., and establishments primarily engaged in other industries produced 55,176,000 lb. These figures indicate that, for the period considered, about 55.2 per cent of lard substitutes were produced by the specialized substitute industry; 39.9 per cent, by the meat-packing industry; and 4.9 per cent, by miscellaneous businesses.

One of the factors that has emphasized the problem of the lard manufacturer has been the increased competition of substitute fats and oils. Especially has their effect been felt on general lard-price levels in years when production of substitutes has been unusually high. Manufacturers of such substitutes have realized the difficulty of competing with lard on a flavor basis, and have therefore devoted their attention to physical qualities which would per-

[1] For more detailed discussion of lard and lard substitutes see the *Monthly Letter to Animal Husbandmen* (June, 1927), of Armour's Livestock Bureau.

mit standardized products and standardized results in baking. The rising percentage of baking outside of the family kitchen has, therefore, emphasized the price competition between lard and lard substitutes more profoundly than ever before.

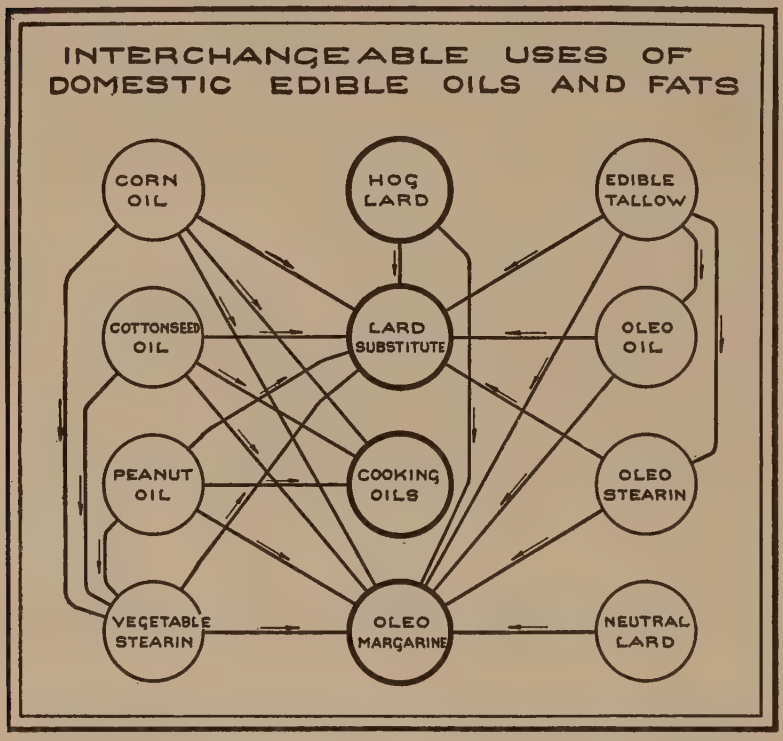


FIG. 20

In general, lard undergoes competition from (*a*) lard substitutes, (*b*) vegetable cooking compounds, and (*c*) hydrogenated vegetable substitutes. Lard substitutes are of several classes (a) one a physical mixture of vegetable oils and animal fats, and (b) vegetable cooking compounds which are physical mixtures of hard and soft vegetable fats. Hydrogenated lard substitutes are prepared by a process of incorporating hydrogen into the molecules of the softer oils, thereby making the resulting product harder and

more stable in structure, and a more perfect imitation of lard, especially in consistency. Usually there is some effect on the flavor, but these vegetable oils, such as cottonseed, peanut, or corn oil, are deodorized so that the flavor is not noticeable.

The principal lard substitute is cottonseed oil, but a variety of products later to be discussed are also used. Whenever any one of these products has a surplus in production, a "bearish" effect is felt on the price of lard. Table XIII and Figure 21 present the fluctuating rates of production of lard and substitutes during the last

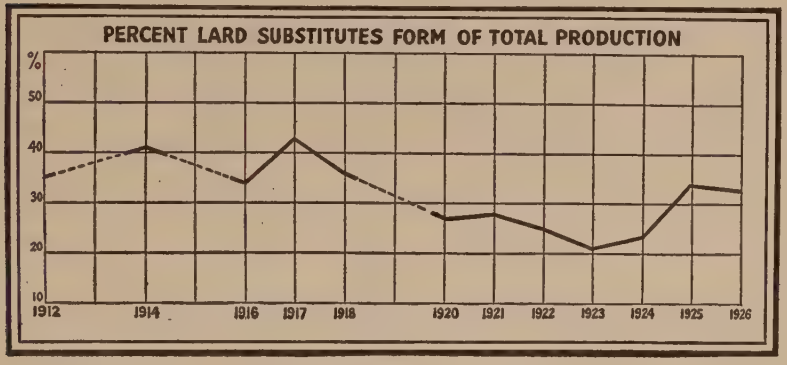


FIG. 21

decade and a half. In general, it will be seen that the war period stimulated high production of substitutes, while the post-war period has shown a falling off in this respect. The large cotton crops of the years 1925 and 1926 materially increased the percentage of substitutes in the total production of shortenings.

RELATIVE PRICES OF LARD AND SUBSTITUTES

Table XIII shows that the relative production of substitutes was smallest in 1923. There is an interesting relationship between the percentage which lard substitutes form of combined lard and substitute production and the relative price of lard and substitutes. This is shown clearly in Table XIV.

Figure 22 presents the percentage relationship of prices and production in graphic form. The price curve is almost the perfect

inverse of the production curve, which relationship is much closer than one would suspect, a priori, from the multitude of factors involved.

Statistical Bulletin No. 18, of the United States Department of Agriculture, presents monthly price relations between lard and

TABLE XIII

PRODUCTION OF LARD AND LARD SUBSTITUTES IN THE UNITED STATES
(IN MILLIONS OF POUNDS)

Year	Lard	Substitutes	Total Production	Percentage of Substitutes to Total Production
1912	1,643	877	2,520	35
1914	1,652	1,137	2,789	41
1916	1,973	1,027	3,000	34
1917	1,577	1,173	2,750	43
1918	2,015	1,146	3,161	36
1920	2,022	756	2,778	27
1921	2,114	819	2,933	28
1922	2,357	784	3,141	25
1923	2,783	751	3,533	21
1924	2,746	830	3,576	23
1925	2,223	1,153	3,376	34
1926	2,324	1,141	3,465	33

TABLE XIV

RELATION BETWEEN PRODUCTION AND PRICES OF SUBSTITUTES

Year	Percentage of Substitutes to Total Production	Percentage of Substitute Price to Lard Price	Pure Lard (Tierces)	Lard Substitutes (Tierces)
1921	28	84	$13.21	$11.06
1922	25	97	13.07	12.68
1923	21	100	13.90	13.91
1924	23	95	14.65	13.95
1925	34	79	17.90	13.12
1926	33	88	16.91	14.84

lard substitutes from 1921 forward. The actual prices are graphed in Figure 23. In general, it will be seen that lard prices tend to rise during the latter part of the year and to be low during the early part. Exceptions occurred in 1921 and 1926, when the general trend of lard prices was downward throughout the latter part of the year, an actual transition to new price levels taking place. In

general, *substitute prices follow lard prices*, although the relationship is not perfect. From 1921 up to the summer of 1926 there was quite a steady rise in substitute prices, but the tremendous cottonseed crop of 1926 "started the toboggan" for both classes of

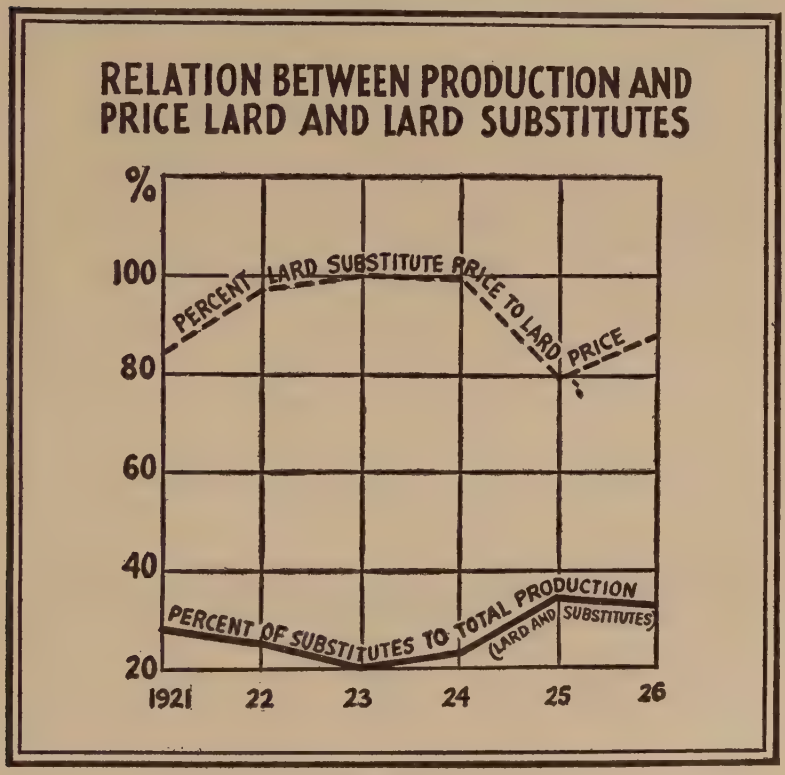


FIG. 22

product. While trend of substitute prices has been upward, they failed to follow lard in its climb following the light corn crop of 1924, and only in the summer of 1926 did they begin to approach their old relationship. Figure 24 presents the ratio between lard and its substitutes, as calculated from the data used in Figure 23. Outside of 1921 it is apparently characteristic for lard to hold favorable relations with substitutes in the fall, and unfavorable relations throughout the middle of the year. The trend is not regu-

lar, but the truth of the general statement seems thoroughly demonstrated.

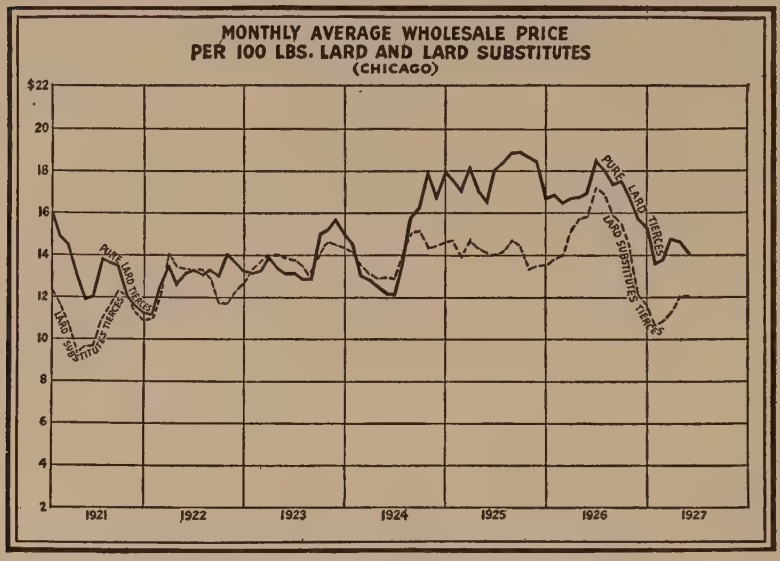


FIG. 23

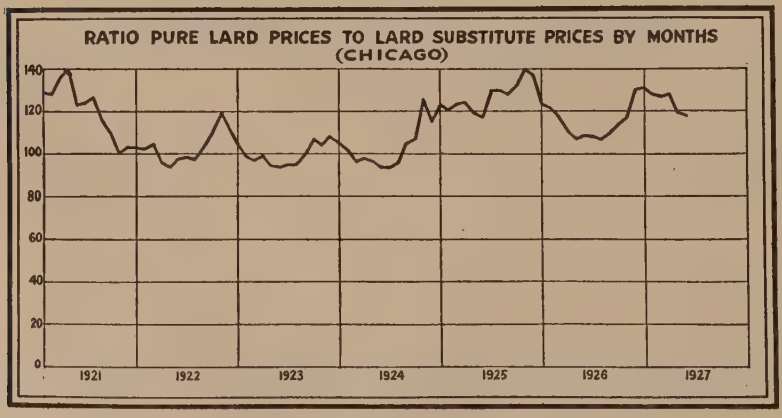


FIG. 24

A more accurate understanding of the problem of substitutes may be obtained by an examination of the kinds and volumes of

oils and fats used in their manufacture. Vegetable oils vary, according to season, in forming from 90–95 per cent of raw materials for this type of manufacture, while animal fats and oils constitute the remainder. The principal vegetable oils, in order of importance, are cottonseed, peanut, coconut, corn, and soy bean, although peanut oil is relatively becoming less important, and coconut oil more important, in the place it occupies in the trade. Table XV is compiled from data presented in a report of the

TABLE XV

PERCENTAGE OF OILS AND FATS USED IN LARD SUBSTITUTES

Fat or Oil	1912	1914	1916	1917	1918	1920	1921	1922	1923
Vegetable:									
Cottonseed	91.7	92.2	88.1	87.5	83.0	80.1	86.6	84.7	84.5
Coconut	.....	.....	.....	0.5	1.1	1.3	0.4	2.1	2.8
Corn	.....	.....	1.3	0.3	0.2	0.9	0.4	1.8	0.9
Peanut	0.2	0.2	1.7	1.0	2.3	6.4	1.9	1.3	0.5
Soy bean	.....	0.1	1.4	2.8	4.6	2.3	1.0	.....	0.1
Miscellaneous	0.7	0.5	1.8	2.5	3.2	0.9	0.9	1.1	1.1
Total	92.6	93.0	94.3	94.6	94.4	91.9	91.2	91.0	89.9
Animal:									
Oleo stearine	6.1	5.6	4.7	4.5	4.5	5.5	5.7	5.7	5.7
Tallow	1.1	1.3	0.9	0.8	0.9	1.3	1.2	1.4	3.1
Pork fat and lard	0.2	0.1	0.1	0.1	0.2	1.3	1.8	1.5	0.9
Oleo oil	.....	.....	.....	.....	.....	.....	0.1	0.4	0.4
Total	7.4	7.0	5.7	5.4	5.6	8.1	8.8	9.0	10.1

United States Tariff Commission which was published in 1926. It presents the situation both for vegetable and animal fats and oils, as a percentage of total production.

COMPETITION OF COTTONSEED OIL AND OTHER OILS

Table XV shows clearly that cottonseed oil is the real basis of the domestic lard-substitute industry. From 1914 to 1918, about one billion pounds of cottonseed oil were consumed annually in the manufacture of lard substitutes, the percentage ranging from 83 to 92 per cent. From 1920 to 1923 there was a marked decrease in the production of lard substitutes, based largely on the falling off in the cotton crop, but also in part on the

relatively low price of lard throughout the post-war readjustment period. The most important factor outside of cottonseed oil is oleo stearine. Tallow may be used interchangeably with oleo stearine, and the two should be considered as a unit.

Peanut oil is declining, and corn oil is rising, as a factor in substitute production. Soy bean oil may ultimately prove an important source of raw materials, although the competition of the paint and varnish industry is sufficient in many years to reduce its

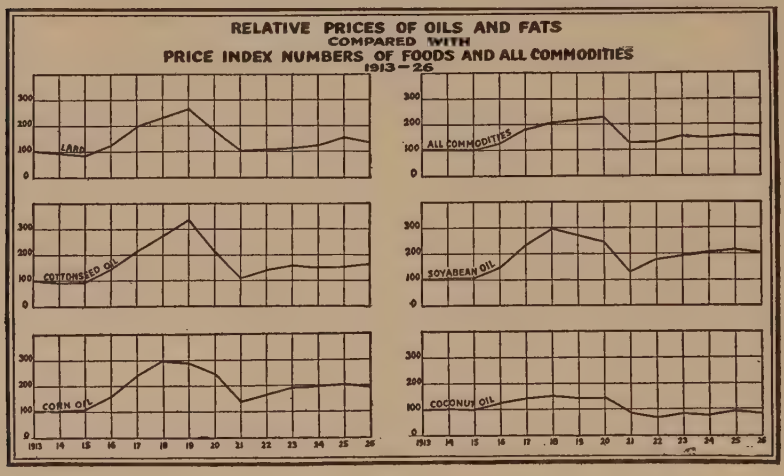


FIG. 25

food use to a minimum. Probably coconut oil will always be more of a competitive factor in the manufacture of butter substitutes than in the manufacture of lard substitutes, because of its tendency to cause foaming when present in amounts over 10 per cent.

Nevertheless, there has been little progress in the substitution of other vegetable oils for cottonseed oil. Hydrogenation can bring a wide variety of liquid vegetable oils, such as soy bean, sesame, and peanut oils into a state of sufficient hardness to provide a consistency comparable to lard. The same processing in Europe is given to fish oil. However, with many of these oils it is necessary to remove the color and characteristic odor; hence, the cost of refining usually more than offsets any advantage in the cost of raw materials.

Figure 25 shows the price trends for fourteen years, in terms of index numbers, for the fats and oils just enumerated, in comparison with all-commodity and food prices. From these it will be seen that lard and tallow have been below their normal relationships to all commodity and food prices. The vegetable oils have in

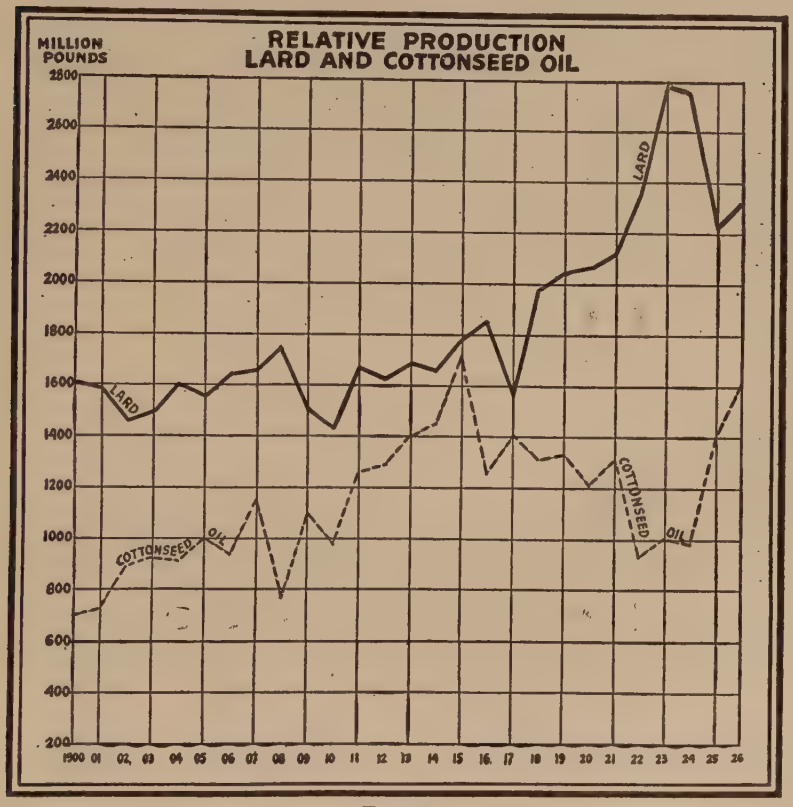


FIG. 26

general been in better circumstances. From 1921 forward corn oil and soy bean oil occupied quite improved positions with respect to all commodities and foods, while cottonseed oil maintained only slightly better than normal relations. Coconut oil, alone of the animal and vegetable fats and oils graphed, is in a more unfavorable situation than it was prior to the war.

Figure 26 presents the relative production of lard and cotton-

seed oil since 1900. In the period just preceding and during the war, cottonseed oil reached extreme heights of production, to fall off materially in the post-war period and to rise again the last two seasons. The production of lard has rather uniformly increased, with a slight recession in 1910 and 1911, due to the short hog production of those years, and with a similar recession the year the

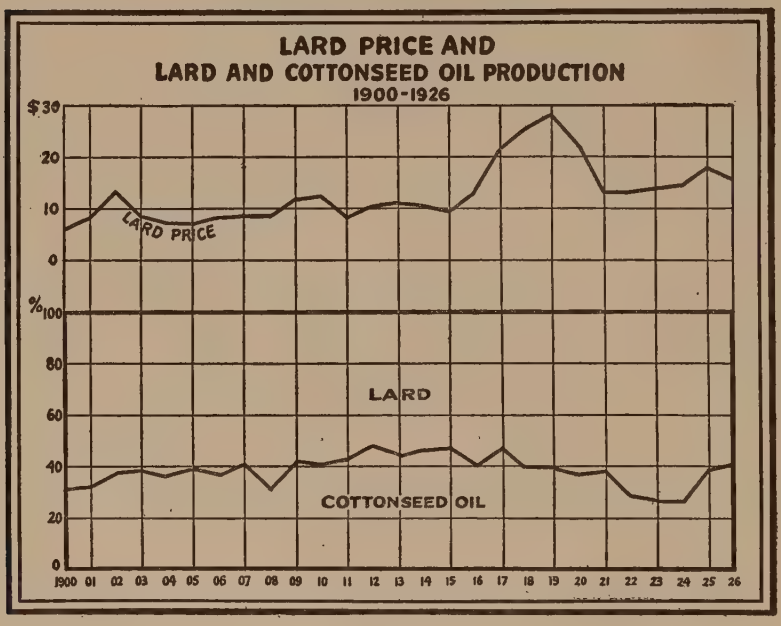


FIG. 27

United States entered the war, when hogs were produced in relatively small quantity, thin, and light in weight. Unusual production peaks were reached in 1923 and 1924 as a result of the tremendous hog crop, but 1925 and 1926 carried forward the trend established from 1912 to 1921.

Figure 27 shows the relative proportion which lard and cottonseed oil have formed in production since 1900. From the opening of the century until 1915, cottonseed oil gained quite consistently on lard, but a breaking point developed about that time, from

which cottonseed oil receded and lard advanced until 1924. Since that time a sharp increase has occurred in the proportion of cottonseed oil, which accounts for the distress evidenced by certain authorities on the lard situation.

In Figure 27 there is also presented the lard price curve, for comparison with the relative proportions of lard and cottonseed oil produced. While there are undoubtedly times when the change in lard prices could be predicted from the change in proportion of cottonseed oil, there are also many periods when the relationship is obscure. On several occasions when lard prices increased in spite of the apparently greater competition from a larger proportion of cottonseed oil, the explanation may be found in Figure 8, which shows that the combined total production of lard and cottonseed oil was falling off, and vice versa. However, the changes from 1925 into 1926 show the typical relation which one might expect.

Cottonseed Oil

It was hardly more than a generation ago that laws were passed in certain states of this country to punish the ginner who accumulated large quantities of rotting cottonseed, or who cast the seed into streams. In those days the only uses for the seed were to burn it in boilers, or to scatter it as fertilizer. Milling and pressing of cottonseed has, therefore, served to encourage the southern farmer, and has added a great value to the products of the South. In 1875 only 6.28 per cent of the cottonseed crop was crushed for oil, while at present some 75 per cent is so crushed. Today the value of cottonseed is about 40 per cent of the total value of the cotton crop itself. In 1860 cottonseed was a garbage; in 1870, a fertilizer; in 1880, a cattle feed; and in 1890, a table food and a useful by-product. From the seed which the ginner once found difficult to give away as a fertilizer, oil is now expressed which is a substitute for olive oil, an ingredient of some highly nutritious prepared foods, including oleomargarine, a cathedral burning oil, a tempering oil, a lubricant for heavy machine tools, a substitute for some fats in soap making and in lard substitutes.

Curiously enough, after the oil is expressed, the seed is better suited for fertilizer and cattle feeding than before. Indeed, a flourishing industry has been built up merely by grinding the caked seed into meal, which is used directly as a feed or fertilizer, or as the principal ingredient of many feeds and fertilizers. For every ton of pressed seed, about 725 lb. of this caked residue are obtained. Even the fiber of the seed, which must be removed before the oil is pressed out and which amounts to 20 or 30 lb. per ton, is used largely in the making of mattresses, felt hats, and pillows, and the hulls, amounting to 1,000 lb. per ton, once burned by the mills for fuel, are sold for cattle feed.

The principal use of cottonseed oil is in the manufacture of lard substitutes. Since these substitutes were produced on a large scale and still are included in the packing industry, their preparation and manufacture are of interest.

Cottonseed oil at present constitutes about 90 per cent of the raw material used in the manufacture of lard substitutes. During the great war fats were scarce and greatly needed for glycerin, which entered into the manufacture of high explosives. The European markets were unable to secure oriental vegetable oils, as they had previously done. Therefore, great volumes of oriental oils came into the United States, were refined, and used to manufacture cooking oil, lard substitutes, and table oils, as well as margarine. These oils included coconut oil, palm kernel oil, sesame oil, rapeseed oil, and a large quantity of oriental peanut oil and soy bean oil.

Since cottonseed oil is the principal constituent of lard substitutes, description of its processing for use in lard substitutes is typical of the handling of vegetable oils. Practically all of the oil milling done in this country is carried on in the South, as the seed is produced there. This seed is marketed during August, September, and October. The first cottonseed oil of the season is usually produced during the latter part of September, and the mills complete the season's pressing by April or May. The big run is therefore in November, December, and January, during which period the mills handle as much seed as possible, because a certain de-

composition of the seed takes place if it is held beyond the usual period of one to seven months, and there is danger of heating, which causes spoilage and resultant poor oil and cake, due to a high percentage of free fatty acids in the crude oil. Texas seed usually produces the best oil in the United States, because Texas seed contains the lowest percentage of moisture. Freshly crushed Texas seed runs as low as 0.5–0.6 per cent free fatty acids, whereas it is not uncommon for some of the seed crushed in the Mississippi Valley in the spring to run from 3 to 5 per cent of free fatty acids. It has even been known to run as high as 14 per cent. Decomposition is generally marked by a considerable darkening in color and a strong flavor and odor.

Methods of Producing Cottonseed Oil

There are two methods of producing oil from cottonseed. The first, and most common, is known as the hydraulic method, and the second, and simpler, is the cold-press method.

In hydraulic milling, the seed is first run through delinting machines to remove the last traces of cotton. A product known as cottonseed linters is thereby produced, from which fiber silk is made, and also many kinds of cotton textiles. After delinting, the seeds are passed through hulling machines, where they are decorticated, and the resulting hulls are sold as forage feed.

The seed, after grinding, is placed in pressure cookers and is discharged into hydraulic presses, where the ground product is forced into all the recesses and is made up into cakes covered with camel's-hair cloth. When a press is fully charged with ground and cooked seed, the oil is squeezed out, leaving the cake in the cloth. This cake is then shaken out of the cloth, ground up, and sold as cottonseed meal, a valuable stock feed, ranking high in protein. The oil produced is pumped from the press cloth into storage tanks and is kept as dry and clean as possible during the period of storage, prior to transfer to the refinery.

In the cold-press method the whole seed, after delinting, is fed directly into an automatic expeller, in which the oil is expelled from the cold seed, and the cake, which consists of both meats and

hulls combined, is sold as a stock feed. While this cold-press method of milling eliminates the great expense of hulling, cooking, and

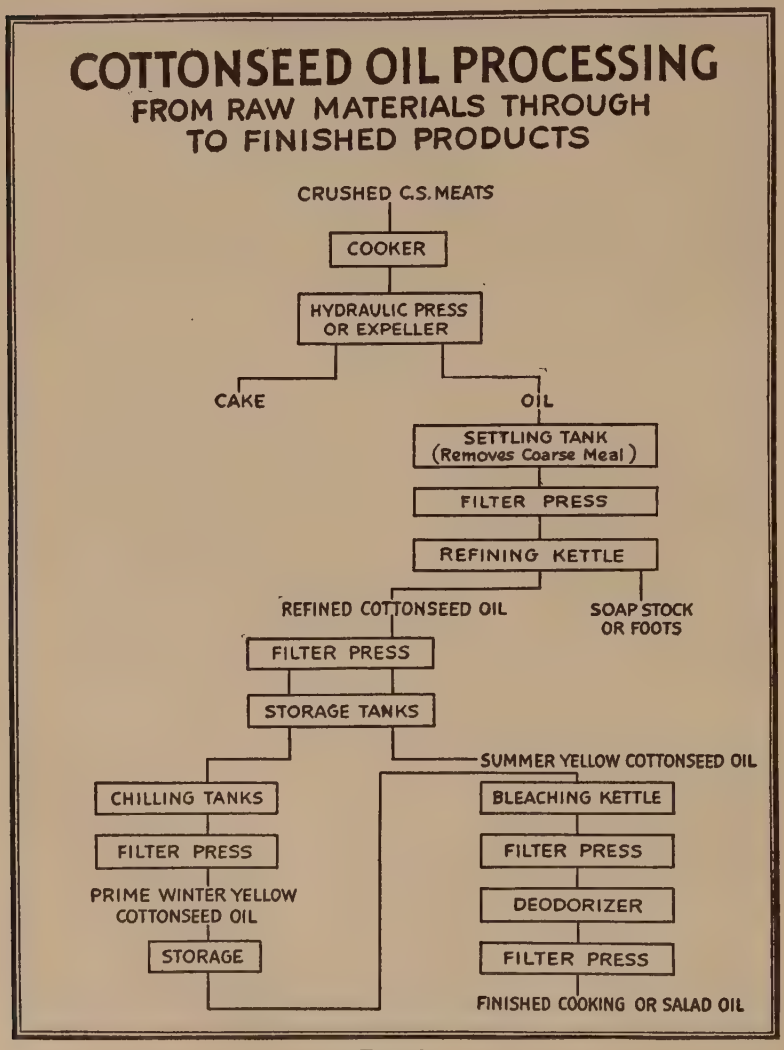


FIG. 28

hydraulic pressing, as well as the labor expense of handling, and may produce a better *quality* of crude oil from the same grade of

seed, hydraulic pressing produces a better *yield* (5–7 gallons of oil per ton of seed) and a more desirable stock feed, for the hulls and cake can be marketed separately. For this reason the latter method is still standard practice.

After pressing, the crude oil is pumped into a tank car for transit from mill to refinery. At the refinery, it is sampled and analyzed, and payment is made upon a basis of the analysis before the tank car of crude oil is unloaded. Following unloading, it is put in a refining kettle, having a capacity equal to one tank car of oil. The kettle has an agitator and a large swimming suction draw-off pipe. Above this refining kettle there is a caustic soda solution tank, and the refining solution may be discharged by gravity into the refining kettle as needed.

In determining the quality and grade of the oil, tests are always made, and on the basis of these tests for the refining of his oil the refiner determines the amount of sodium hydroxide required to neutralize the oil, and the additional amount needed to throw down the coloring matter and to make the soap stock settle out. The oil is first agitated and the contents of the kettle are heated to about 85° F. before refining them. At this time the necessary amount of caustic soda solution is sprayed into the oil in the kettle, the contents are thoroughly mixed, steam is turned into the coils and heating jacket, and the contents of the kettle are heated up until a proper break appears. When the time has come for steam and agitation to be shut off, the soap stock will be heavy enough to settle down to the bottom, leaving the clear refined oil at the top of the kettle. The contents are allowed to settle for several hours, and the refined oil is then drawn off from the kettle through a large suction pipe. The soap stock is taken from the bottom, carefully skimmed in order to have it free from oil, and is then sold to soap makers. The refined oil is carefully settled, filtered, and dried, and transferred to the bleaching kettle, where the cottonseed oil is bleached by a process similar to that of pure lard bleaching, though it requires more fuller's earth. When the oil is bleached it is called prime summer white cottonseed oil. This cottonseed oil is deodorized to eliminate its natural odor as

well as the odor of the fuller's earth, which is produced by the heavy bleaching reaction used to remove the dark color.

Early methods of deodorizing employed open kettles, where steam under pressure was simply blown through the oil. Later, superheated steam was used, and finally vacuum deodorizing kettles were made. These deodorizers were connected to condensers and vacuum pumps, the oil was kept under a high vacuum, and superheated steam was passed through it so that the volatile fatty acid containing the flavoring and some of the coloring matter in the oil were distilled over and eliminated. Recent improvements in deodorizing methods include the use of the direct and indirect heating systems. The oil is heated by passing it through coils in a furnace, or heated mineral oil is circulated through coils placed in the vegetable oil itself. Samples are taken from time to time, and when a neutral flavor is reached, the oil is cooled down to about 110° F. It is then pumped away and is ready for the market in the form of "cooking oil." In making lard substitutes the mixture of oil and stearine is deodorized.

About 84 per cent of deodorized cottonseed oil, mixed with about 16 per cent of oleo stearine, forms compound lard. After mixing, the product is run over a lard roll in a manner similar to prime steam lard, in order to give it increased heat resistance and to whiten it. In making a lard substitute, the purpose is to reproduce closely the physical characteristics of pure lard. Therefore, some ingredient is added which will give a melting-point to cottonseed oil that will approximate that of pure lard. Formerly about 38 per cent of tallow was added to the oil, and the standard method for a long time was the addition of 13–18 per cent of oleo stearine. These ingredients were weighed in a scale tank, running the oil in first and then the stearine. They were mixed together and filled into packages by passing over a chilled cylinder in a manner similar to that of chilling and filling pure lard. The only difference between the methods of chilling and filling compound lard and pure lard is that the compound lard is usually held at a higher temperature when feeding it upon the lard cylinder, and the roll is kept colder. Even under the best conditions, however, lard sub-

stitutes are not as white as pure lard, but sharper chilling and more beating in the picker box produces a whiter compound lard.

Within the past ten or fifteen years the process known as "hydrogenation" has come into existence. About 10 per cent of fully hydrogenated cottonseed oil is mixed with 90 per cent of straight deodorized cottonseed oil to produce a lard substitute. It is also run over lard rolls like compound lard. Frequently the oil is only partially hydrogenated, to approach as nearly as possible the consistency of pure lard, and this partially hydrogenated oil is run over the lard roll to produce another form of lard substitute. Furthermore, deodorized cottonseed oil becomes a solid if placed in the household refrigerator. In order to produce a cottonseed oil that will remain liquid at low temperatures, the oil is slowly cooled, and the stearine, or hard fatty acids, are extracted by means of a filter press. The resulting oil is "salad oil."

Processing Other Vegetable Oils

Most of the other vegetable oils are processed like cottonseed oil, with a certain number of minor differences due to special characteristics of each crude material and the resulting oil. Coconut oil is extracted by means of the Anderson expeller. After the seeds have been thoroughly ground up, the oil is pressed, filtered, neutralized, bleached, and deodorized. It is used largely in "nut" margarines, in baking, making confections, etc. Peanut oil is also produced by grinding the nuts in an expeller, filtering the oil, and refining it by the cottonseed-oil process. This peanut oil is used in lard substitutes and in cooking and salad oil. Produced from good sound nuts, peanut oil is of fine quality; but because of the great demand for prime nuts by confectioners and bakers, only second-grade nuts go to the peanut-oil mill, as a rule, just as only second-grade olives are used for olive oil.

Corn oil is produced by degerming corn (removing the germ), extracting the oil from the corn germ by means of an expeller, and then filtering and processing like cottonseed oil. As it contains a very large amount of resinous and mucilaginous matter, the neutralized oil is treated in the cold with diatomaceous earth,

a very finely pulverized earth possessing remarkable filtering and clarifying qualities. After this treatment the corn oil is passed through a filter press before finishing. Corn oil is used as a salad and cooking oil only, as it remains liquid at very low temperatures. Soy bean oil, rapeseed oil, sesame oil, and other vegetable oils are made in essentially the same way.

Exports of Lard Substitutes

The available official export figures on the various vegetable oils and the products of vegetable oils are often somewhat confusing, depending on the source from which they are drawn. The curve showing exports of vegetable oils presented in Figure 29 was prepared from data furnished by the Department of Commerce and the Tariff Commission, plus cottonseed oil figures converted to pounds from gallons (7.5 pounds to the gallon) as furnished by the Bureau of the Census. The year 1917 seems to be quite abnormal, since the export of vegetable oils is more than three times that of any previous year. However, this large increase is suggested in all the data secured; hence it is probably correct. In general, it will be seen that the export of vegetable oils since the war has declined tremendously.

Figure 30 presents the same data converted to a percentage basis. This emphasizes still more strongly the high cottonseed-oil production of 1917, and the tremendous post-war decrease. Since cottonseed oil provides such an enormous source of the vegetable oils, Figure 31 has been prepared to show the proportion of cottonseed oil exported. It will be seen that lard varies between 30 and 40 per cent, although in 1906 it reached 45 per cent, and in 1921, $42\frac{1}{2}$ per cent. On the other hand, the proportion of the cottonseed oil exported has been decreasing continuously, with the exception of a single war year in which $12\frac{1}{2}$ per cent more oil was exported than was produced during the year, a condition made possible, of course, by the carry-over from the previous year.

The most significant fact brought out by these graphs is that the competition of American vegetable oils is felt by lard much more definitely in the domestic trade than in the export trade.

The decline in the exports of cottonseed oil was initiated previous to the war, and was in line with the general decrease in exports of

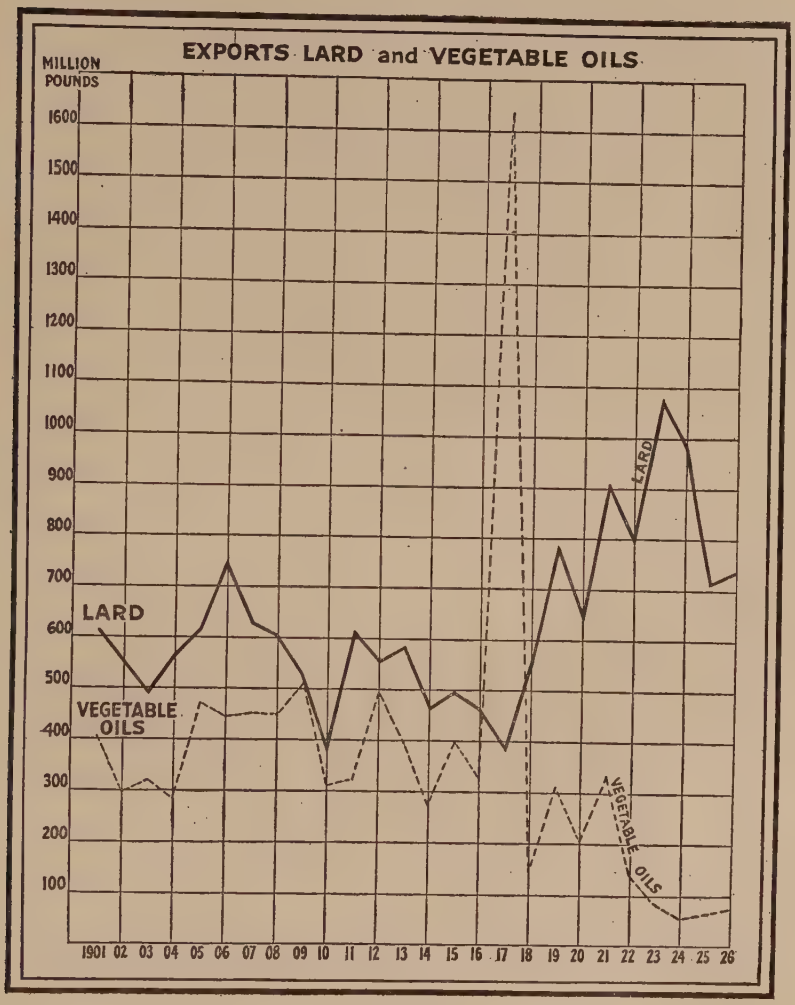


FIG. 29

American foodstuffs. The war-time demand in Europe stimulated the substitution of many cheaper oils, namely, soy bean, whale, and fish oils. Since the war, the European countries have been

largely importing their own raw materials, such as copra, peanuts, soy beans, palm kernels, and Indian and Egyptian cottonseed, thereby replacing much of the American cottonseed oil previously exported. Furthermore, the advance of the boll weevil and other unfavorable conditions reduced the cotton crop in the United

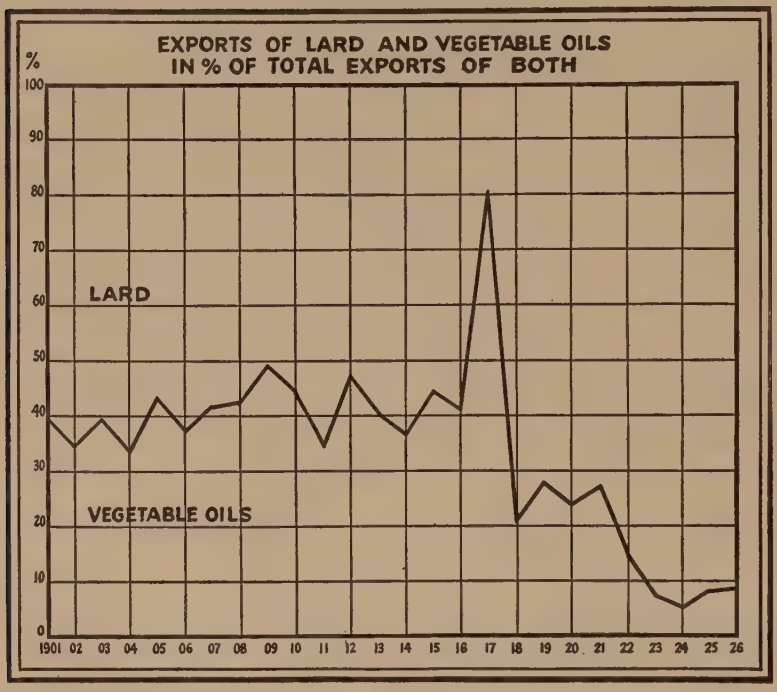


FIG. 30

States materially from 1921 into 1923, and thereby contributed to the reduction of exports.

In the search for significant factors creating what appears to be a present unfavorable situation in the lard market, many people have called attention to the competition of so-called "Dutch lard." This lard is manufactured by certain Dutch processors who import white grease from the United States and who, by bleaching and deodorizing, produce an article which can be worked with tallow into their own lard product. Because of the

price of this resulting commodity they have been able to distribute it on a considerable scale throughout western-European countries. The reduced purchasing power of these nations since the war has made this business profitable; but in the last year several factors have combined to lessen the importance of this competition. In

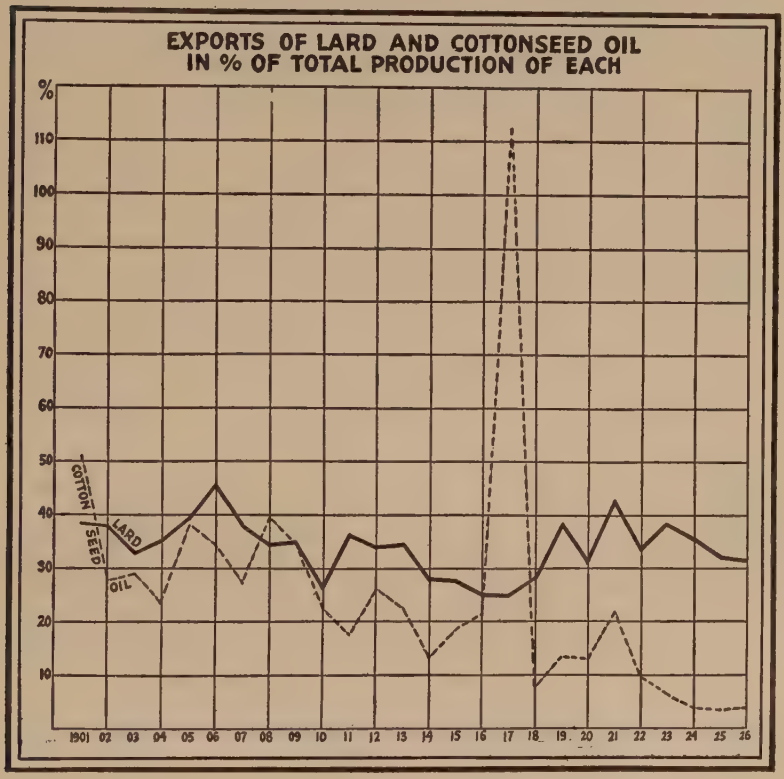


FIG. 31

June, 1925, Dutch lard was excluded from Great Britain, while several months later it was also excluded from Germany.

Figure 32 presents a study of the imports of animal fats and oils into the Netherlands from the United States. The general trend, of course, involved a drop in imports with the opening of the war, despite the previous rising trend. The close of the war

saw a reversal, and since that time exports increased materially up to 1924. The principal item of increase was in animal fats and greases, although in 1926 there was a marked increase in fish oils. The reduction in 1925 and 1926 as compared to 1924 seems to be general in all other animal fats, with the exception of neutral lard and the higher-grade fats. Tallows and greases, especially, de-

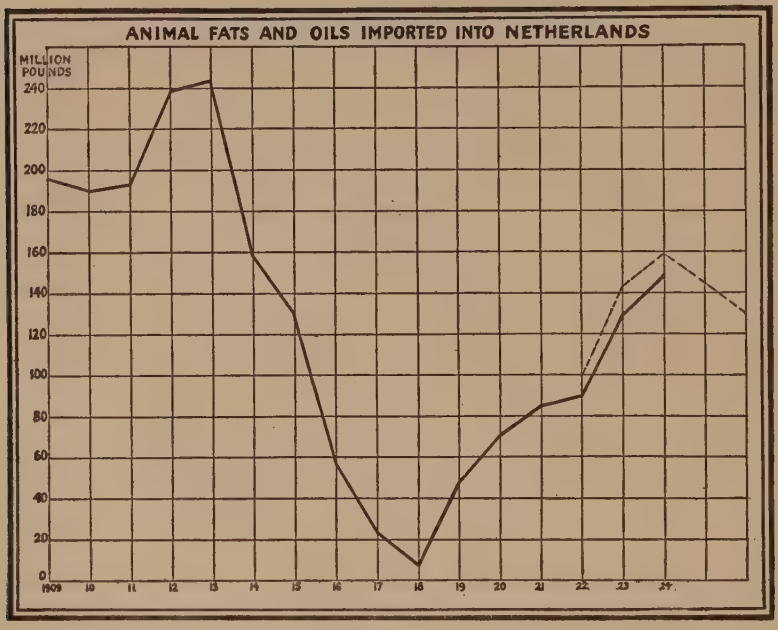


FIG. 32

clined in 1926. Certainly there is nothing in the immediate situation to warrant any further concern over the competition of Dutch lard.

OLEOMARGARINE[1]

Oleomargarine is a scientific preparation of two or more of the finest edible fats, in combination with milk. Of total constituents, animal fats average about 37 per cent. In what is more strictly called animal margarine, animal fats form 80 per cent, and vege-

[1] See also the *Monthly Letter to Animal Husbandmen* (March, 1927), of Armour's Livestock Bureau.

CHURNS FOR OLEOMARGARINE MANUFACTURE

OLEOMARGARINE COMING FROM CHURNS

table oils, 20 per cent. Milk is the one indispensable factor used in making margarine. It not only provides the desirable flavor, but is a valuable food supplement. It contains nearly all of the food elements necessary for the growth of infants and children, although the amount remaining either in butter or oleomargarine is not sufficient in itself for a complete food. Milk is also a valuable factor in manufacture, since fats can be more easily and economically emulsified in milk than in any other agent. There must be a certain degree of emulsification of fats before the desirable texture and appearance can be secured that is required in oleomargarine.

Oleomargarine was discovered some sixty years ago and has proved a distinct contribution to the dietary of man, as well as to various producers of raw agricultural materials. Millions of pounds of animal and vegetable fats and oils are placed in a convenient and palatable form through oleomargarine manufacture. For over fifty years it has been used in the United States, and its annual consumption during the last half-decade has averaged about 225,000,000 lb. This is over 2 lb. per capita, and compares with an annual butter consumption of 1,905,000,000 lb. or a per capita consumption of about 18 lb.

Oleomargarine is produced in some sixty factories throughout the United States. The reason for this comparatively small number of factories lies in the fact that it is unlawful in all states to allow manufacture in a creamery or dairy. Manufacture takes place only in plants at which skilled corps of meat inspectors are located and at which there can be an inspection of the vegetable oils, the oleo oils and fats, and the milk and butter used. Since its discovery, margarine has demonstrated that it is a scientific food achievement, that it supplements the fats in the human dietary and fills a field which would largely be unoccupied if its manufacture were further restricted or discontinued.

There are two kinds of oleomargarine in the trade. One is made primarily from animal fats and oils, with salt and milk and a certain proportion of vegetable fats added. The other uses the largest proportion of vegetable oils, perhaps without any admix-

ture of animal fats, is churned with salt and milk, and is commonly called "nut margarine." The total volume of materials used in the manufacture of oleomargarine for the fiscal year 1926 is given in the *Annual Report of the Federal Commissioner of Internal Revenue*, as follows:

	Pounds
Milk	72,662,310
Coconut oil	98,307,340
Butter	2,330,320
Color	40,763
Corn oil	173,733
Cottonseed oil	25,608,341
Edible tallow	93,038
Mustard oil	33,645
Neutral lard	25,172,425
Oleo oil	47,418,248
Oleo stearine	5,313,502
Oleo stock	3,082,251
Palm oil	860,734
Palm kernel oil	276,816
Peanut oil	5,257,202
Salt	20,592,622
Sesame oil	185,720
Soda	58,657
Soy-bean oil	790
Vanilla extract	315
Total	307,459,772

Over a period of years the chief ingredients in the annual production of oleomargarine are: animal fats and oils, 128,298,000 lb.; vegetable oils, 129,130,000 lb.; and milk, 76,662,310 lb.

The information at present available regarding the digestibility of oleomargarine has resulted largely from the work of European investigators. Flurin determined the digestibility of oleomargarine eaten in conjunction with a basal ration consisting of boiled meat, buckwheat grits, and white or dark bread, and found in ten tests that the oleomargarine was 94.82 per cent digested. Mayer compared the digestibility of oleomargarine consumed by a thirty-nine-year-old man and a nine-year-old boy, and obtained respective figures of 96.4 per cent and 95.8 per cent. Snyder found

that oleomargarine, eaten as a part of the ration, showed an average digestibility for the protein of 87.9 per cent; for the fat, of 94.2 per cent; and for the carbohydrate, of 97.01 per cent. Luhrig reports the digestibility of three separate grades of oleomargarine as 97.35, 97.39, and 97.9 per cent, respectively. Wibbens and Hinzenga obtained a digestibility of 96.03 per cent; Kienzl, of 95.68 per cent; and Hultgren and Landergren, of 94.45 per cent. These figures compare very favorably with butter.

In recent years the discovery of vitamins, and especially of the fat-soluble Vitamin A, has provided a basis of discrimination between different fats. The discovery that milk and butter are rich in these vitamins was used for a long time as a selling argument in behalf of these products, and as a reason for restricting consumption of other fats. More recent investigations have shown a wide prevalence of vitamins in fats other than butter, and much of the basis for discrimination, except in the case of small children or of diets restricted from the standpoint of diversity, has been removed. The volume of butter and milk used in oleomargarine manufacture, and the proportion of animal fats as compared to vegetable fats, has destroyed the principal ground for criticism on this score. In a broad sense, oleomargarine may safely be used as a factor in any mixed or varied diet without any danger of disturbance through vitamin limitation.

Invention of Oleomargarine

Oleomargarine as a definite food product was first invented by Hippolyte Mege, who developed the method of manufacture in 1869 at the Royal Farm at Vincennes, France, for which he received the prize offered by Napoleon III for a palatable table fat which would be cheaper than butter, keep better, and be less subject to rancidity. The margarine of Mege was an oleo-oil product, while modern margarine is a mixture of animal and vegetable fats, or, in some cases, vegetable fats alone. During the Franco-Prussian War of 1870 the nutritive value of oleomargarine was established, especially in the semi-starvation days during the siege of Paris.

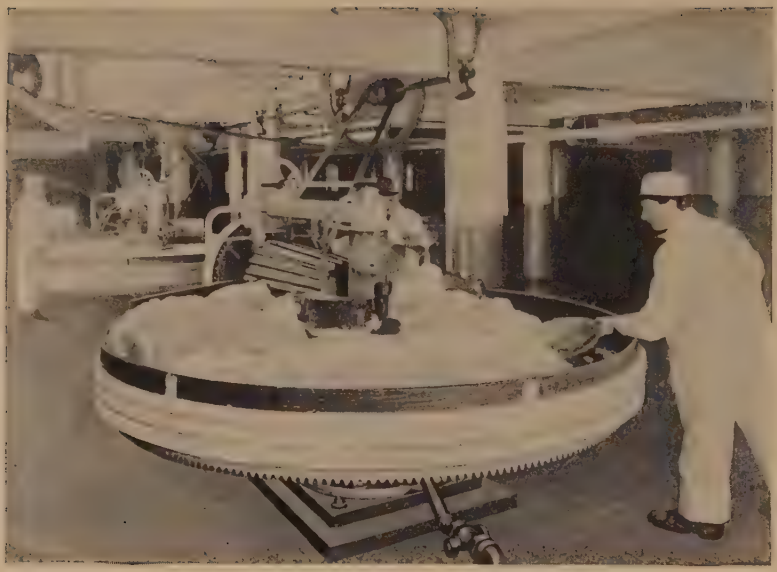
The name "margarine" was first applied by Chevreul to what was at that time considered to be a definite single compound of margaric acid with glycerin, and which was believed to occur in human fat and in olive oil. However, research showed that this so-called "margaric acid" was in reality a mixture of stearic and palmitic acids, and the term "margarine," therefore, did not represent a definite chemical substance. The name "oleomargarine" was introduced to signify what was believed to be a mixture of the two fats, olein and "margarine," from which stearine had been separated. Part of the "margarine" is now known to consist of stearine and palmitin, so that oleomargarine still contains these two fats, though to a much lesser degree than in the original beef or mutton tallow. The softer fat, from which the stearine has been removed, is "oleo oil," and the final product made therefrom is called "oleomargarine."

The principal departure from the methods of Mege, during recent years, has come from the introduction of greater proportions of vegetable fats and oils. The increase in the consumption of the class of margarines known as "nut butters" during recent years has been phenomenal. This change has been occasioned largely, if not solely, by the relative abundance of the supply of raw materials, and the favorable price ratios existing. The production of animal fats has not kept pace with the increase of population, while the supply of vegetable fats and oils of temperate, and especially of tropical, origin can apparently be increased almost indefinitely.

The Wide Use of Oleomargarine

Oleomargarine was first used because no other spread for bread was available for the poorer classes of Europe—with the possible exception of drippings—since the price of butter was prohibitive. Furthermore, very little shortening for cooking purposes was available in the form of the heavier fats. The preparation of oleomargarine relieved these wants.

While in its genesis and early history it was to be considered a substitute for butter, it soon spread into a field where butter had not previously been available. It must be remembered



WORKING OLEOMARGARINE

PACKING OLEOMARGARINE IN CARTONS AND BOXES

that butter is used in a comparatively small area of the earth, principally North Europe and America; and in many sections of the globe it is not used at all. In the Mediterranean countries, for example, olive oil is the chief fatty product used both for ordinary consumption and for cooking; while in eastern Europe and Asia, tallow drippings are similarly used. In fact, in the greater part of the earth's area, among the rice-consuming peoples, few fats and oils are used at all in admixture. While oleomargarine is manufactured and sold in every civilized country, the use of butter is restricted to the wealthier nations only, although from conditions in the United States one might consider butter almost a universal and necessary product. However, the use of butter is greatest with races of northern-European origin, who have cultivated a taste for fats carrying the so-called "lactic flavor," while the more southern races demand olive oils and other oils lacking this flavor. Since the northern-European races are also the principal consumers of oleomargarine, it is only natural that the lactic flavor should have been imparted to it.

Scientific study of oleomargarine manufacture has brought about improvements which have resulted in a shortening equivalent in many cases to butter, and in certain instances one that is preferable to butter. Practically all bakers find oleomargarine the most suitable for the preparation of certain of their products, while its use is spreading for both cooking and table purposes in the better class of homes. Generally speaking, the big demand for oleomargarine begins about the middle of September and continues until the middle of May, although in many sections its use is quite uniform throughout the year.

Because of the methods of production and handling of both animal and vegetable fats and oils in margarine manufacture, it is possible to enforce even stricter standards of sanitation and manufacture than in the case of butter. The majority of margarine plants are sunlighted and tile finished. The tanks are glass lined, so as to permit perfect sterilization, and the churns and utensils are so devised as to be sterilized automatically after each manufacture, without being touched by human hands. One of the prob-

lems in producing a perfect product is the so-called "seeding" of the oleo fats. This is accomplished by using iced water after churning, which crystallizes the fats in granules or "seeds" similar to the "gathered" butter as it comes from the churn. Following crystallization the fats are conveyed to the tempering-room, where they remain until the flavor of the milk permeates the entire product. After that the mixture is conveyed to machines which remove the excess milk, salt, and moisture before it is pressed into the various shapes, inclosed in sanitary containers, and packed ready for delivery.

American Production and Consumption

The volume of the American domestic oleomargarine trade is indicated in Table XVI.

TABLE XVI

Year Ending June 30	Total Production (Pounds)	Total Consumption (Pounds)	Per Capita Consumption
1909	92,282,815	89,337,664	0.99
1910	141,862,280	138,026,520	1.51
1911	121,162,795	117,590,862	1.26
1912	128,601,053	124,666,822	1.32
1913	145,327,862	141,858,629	1.48
1914	144,021,276	141,878,107	1.46
1915	145,810,048	140,157,551	1.42
1916	152,509,913	146,752,525	1.47
1917	233,170,111	226,523,373	2.23
1918	326,528,839	319,629,407	3.11
1919	359,216,571	341,661,307	3.28
1920	391,283,143	368,783,386	3.49
1921	281,081,514	276,992,980	2.59
1922	190,950,373	188,674,600	1.74
1923	209,182,188	206,773,240	1.88
1924	239,698,749	238,613,604	2.14
1925	215,402,538	214,557,135	1.90
1926	234,866,321	232,166,482	2.06

The largest part of the oleomargarine sold in the United States is white, or nearly so. The ingredients used in its manufacture do not contain a sufficient amount of color to impart a yellow tint to it. Some states prohibit the sale of oleomargarine carrying any shade of yellow, on the ground that it may be mistaken for butter. If colored a federal tax of ten cents per pound is imposed;

while if free from artificial coloring, the tax is one-fourth of a cent per pound. This virtually amounts to a tariff in the competition of oleomargarine with other fats. No such tax has ever been levied on any other article of food. In fact, the oleomargarine manufacturer is not permitted the usual responsibility, accorded any other manufacturer, of marketing his product in a form to attract the eye of his customer. If the housewife desires added color, she must either mix the little capsule of color that goes with each retail package of margarine upon the request of the purchaser, or else she must eat a white product.

While there were undoubtedly many cases of misrepresentation of oleomargarine for butter previous to the passage of the federal law, additional prejudice was engendered against oleomargarine as a food, which was entirely unwarranted. Much of the attitude which developed was the result of the mistaken idea that a manufacturer of synthetic materials was competing with the dairy industry. Even today it is not generally understood that the beef-cattle producer and the grower of cotton benefit directly to the extent in which their products are incorporated into oleomargarine, and taxes of the type mentioned really operate as a barrier to free competition between different classes of farmers. The beef-cattle man has no protection against the dairy cows which are by-products of the dairy industry once they are sent to market for slaughter, and it seems only fair that the beef-cattle man should be given a similar free market for his fats, especially within the boundaries of this country.

Anti-Oleomargarine Legislation

For years after its discovery, oleomargarine was hailed as a great blessing to humanity; but gradually opposition began to develop. Proponents of competing products declared it was impossible that, by manufacture, a spread for bread could be produced that would be absolutely pure, nourishing, and healthful when the only process in its manufacture was a simple churning with cow's milk. These persons, of course, did not realize the efficacy of milk as a source of flavor and as an emulsifying agent.

The first federal law dealing with the distribution of oleomargarine placed a two-cent tax per pound on it, irrespective of color. In 1902 the law was amended, a tax of ten cents per pound being placed on the colored product, and one-fourth cent per pound on the uncolored, providing the product entered interstate commerce. Since that time many states have passed additional legislation of a similar nature to govern the production and trade in margarine from an intra-state standpoint. In many cases laws of a most unjustly discriminatory character have been adopted. All over the country a continuous fight has been carried on against it. Originally there were many legislators who were undoubtedly inspired by a sincere desire to enact laws that would place the industry and the butter manufacturers on a fair competitive basis. However, this period is long past, and the majority of laws under consideration in the different states where legislation was proposed this last winter have been of a nature that would seriously inhibit, or even prohibit, trade in this product. The prejudice which was first developed on the grounds of substitution for butter, and amplified by the popular fads concerning vitamins, has been used by industries which believe themselves to be affected adversely by the production of oleomargarine as a means of securing legislation of the type mentioned.

Today the federal margarine law taxes artificially colored margarine ten cents per pound, wholesale dealers, $480 each, retail dealers, $48 each, and manufacturers, $600 each, per annum. In addition, many states have laws requiring further taxes. No other industry or food product is similarly treated. Many states prohibit the manufacture and sale of artificially colored margarines, but do not prohibit the manufacture and sale of any other artificially colored article of food. In some states uncolored margarine is subject to similar laws, and in cases where the production and sale are not absolutely prohibited, they are prevented by taxes and license fees that act as an embargo.

One state law requires margarine to be labeled "a substitute for butter," while a neighboring state prohibits exactly such a label. Yet the same influences were used to secure the passage of

both laws. Another state law requires that the names of the ingredients of margarine be put upon the label, while it also has a law which unqualifiedly prohibits the use of the words "milk" and "butter" in connection with margarine labeling and advertising. Yet milk is an ingredient of every pound of margarine sold in this state, or, for that matter, of every pound made in this country. Butter is used in margarine to the extent of two to six million pounds annually. Hence there is a situation in several states in which it is lawful to make and sell a product, but unlawful to tell of what it is made, or how it is made.

A great effort to obtain the passage of further state laws controlling margarine sale and production was made in 1925 and was duplicated in 1927. Most of the bills fell into one or more of the following classifications: (1) To prohibit the manufacture and sale of margarine. (2) To prohibit the use of milk or milk products in making margarine. This would prohibit the manufacture, since there is not a pound of margarine made in this country without milk. (3) To tax all types of margarine five cents per pound, in addition to the federal tax. (4) To prohibit state institutions from buying or using margarine. (5) To prohibit the use of vegetable oils with milk in the production of margarine. (6) To prohibit the use of any kinds of fats and oils with milk in the manufacture of margarine.

A highly significant fact in the whole situation is the relatively large consumption of oleomargarine in rural districts. About one-fourth of the margarine produced is marketed on farms, especially in the dairy sections. In Table XVII the states shown are primarily large producing dairy states. They are also the states in which further restrictive legislation has been advocated for oleomargarine manufacture and distribution. Yet each of these states either produces or distributes oleomargarine far in excess of the requirements of the population, as determined on an average basis.

In examining Table XVII, it will be observed that California, for example, whose population is only 3.6 per cent of the total of the United States, manufactures 10 per cent of the oleo produced, and has 7.5 per cent of the total retailers selling oleomargarine in

the whole country. Iowa has a population of only 2 per cent of the country's total, yet it has 4.2 per cent of the dealers selling the product. In the case of Kansas, there is only 1.5 per cent of the total population, while there is 3.2 per cent of the total retailers. On the other hand, a predominantly urban state, like Pennsylvania, has 8.1 per cent of the total United States population, and only 2.3 per cent of the retailers.

TABLE XVII

COMPARISONS OF POPULATION IN CERTAIN STATES AND PRODUCTION AND SALE OF OLEOMARGARINE

(FISCAL YEAR ENDING JUNE 30, 1926)

State	Estimated 1926 Population	Percentage of Total U.S. Population	Pounds Oleo. Production, Uncolored	Percentage of Total Production	Number of Retailers Selling	Percentage of Total Dealers
California	4,316,000	3.6	23,597,438	10.0	11,974	7.5
Colorado	1,059,000	0.9	586,640	0.2	2,227	1.4
Idaho	522,000	0.4	.....	.....	592	0.4
Illinois	7,203,000	6.1	112,989,279	48.1	14,514	9.1
Indiana	3,124,000	2.6	2,529,052	1.1	9,547	5.9
Iowa	2,423,000	2.0	.....	.....	6,630	4.2
Kansas	1,821,000	1.5	16,793,826	7.1	5,110	3.2
Michigan	4,396,000	3.7	659,250	0.3	10,394	6.5
Minnesota	2,651,000	2.2	3,322,668	1.4	4,386	2.7
Missouri	3,498,000	2.9	10,699,596	4.6	6,592	4.1
Montana	695,000	0.6	.....	.....	50	0.03
Nebraska	1,385,000	1.2	2,200,847	0.9	3,028	1.9
Pennsylvania	9,614,000	8.1	.....	.....	4,141	2.3
South Dakota	689,000	0.6	.....	.....	1,006	0.6
Tennessee	2,468,000	2.1	149,320	0.06	1,917	1.2
Washington	1,538,000	1.3	780,120	0.3	3,643	2.3
Wisconsin	2,885,000	2.4	6,397,420	2.7	4,802	3.0
United States	118,628,000	.....	234,866,321	.....	159,662	.....

EXPORT TRADE IN ANIMAL FATS AND OILS

Since 1920, certain important meat fats have declined in volume in the export trade, but the volume of meats themselves has declined more definitely than the fats. The following six items—fresh and pickled beef, fresh pork, cured and pickled pork, lard, neutral lard, and oleo oil—showed from 1924 to 1927 a consistently downward trend in volume. Prices went up, but not enough to maintain the total value at the previous level.

During the first years after the war, European agriculture was

expected to be at a low level and to require supplementing with American foodstuffs. Production was therefore increased to meet this supposed situation. Then came the post-war crisis in 1920 and 1921, and a period of stagnation, followed by a slow readjustment and the new competition of Denmark, Sweden, Holland, and the Baltic states. About 1923 there was excessive domestic production in the United States, with two bumper corn crops, resulting in too great an amount of pork products, which caused prices to drop so that impoverished Europe could buy. As the surplus was gradually reduced during 1924, the natural downward trend of volume in the export trade resumed, and continued to the end of 1926, when it was only 63 per cent of the 1921–25 average. This depression was partly due to the high prices.

It is logical to expect the downward trend which began in 1900 to continue and become permanent. Beef exports are not only practically negligible, but also regularly declining, though the monthly fluctuations are small. This stability, likewise, is reflected in the oleo oil trade, but the downward trend is scarcely as pronounced as in the case of beef. Exports of pork vary greatly in volume, and clearly display the trends of the hog cycle. Sales of the fresh products, however, are much more sensitive to change in production than those of the cured, which may be kept in storage when the market temporarily turns against them. The trend of lard exports suggests that this trade is much more stable as far as volume is concerned. This is especially true of neutral lard, which is only slightly involved in the general downward tendency.

The different trend for the two groups of products implies that the future outlook for our meat-export trade is problematical. The downward trend initiated at the beginning of the century, however, is likely to continue until this trade loses its significance. Our meat production in the future will apparently be based on the home market alone, due to the better price levels which the domestic trade supports compared to the foreign trade.

Animal fats, however, will probably maintain their position in our future foreign commerce. For every 100 lb. of pork produced,

about 27 lb. of lard are obtained as a by-product. For every 100 lb. of pork consumed, only 20 lb. of lard are sold. The balance of 7 lb. finds no market in this country, and must, therefore, be shipped abroad. The tendency to base agricultural production more on domestic consumption will gradually reduce the significance of the foreign trade in meats. Even if this readjustment were ideal, there would still remain an available surplus of the fats obtained as unavoidable by-product, at least as long as the present methods of hog raising are maintained.

CHAPTER VI

SOAP

Modern soap manufacture is a complicated industry in which millions of pounds of different kinds of soap are produced each year and sold in national and international trade. Since tallow is one of the chief ingredients used in many soaps, and is at the same time a product of the packing industry, it was natural for the national packers to add soap manufacture to their activities. As soap makers, meat-packing companies are always assured of large volume and selection of raw materials, and a constant supply of uniform grades of soap stock.

Soap is produced in about 270 factories throughout the United States, and the total value of all products of the soap industry in 1925 amounted to $270,000,000, compared with $128,000,000 in 1914. Of this total, soap itself accounted for $230,000,000. The products other than soap had a value of over $40,000,000 and included such articles as glycerin, stearin, candle pitch, and red oil. The most interest attaches, of course, to the main product, soap. This is manufactured in many forms, and, in fact, it is more instructive to consider the quantities of the various soap products than to think only in terms of soap as a single article. For there are hard soaps and granulated and powdered soaps, soap powder, liquid soap, face soap, and finally soft soap. A comparison of the quantities of each kind of soap produced in 1925 and 1914 indicates a pronounced trend toward greatly increased production. While the census figures are very inadequate there has been a considerable increase in the production of hard soaps since 1914; and certain types of soaps like toilet soap and soap chips have doubled in quantity produced. New forms of soap, such as liquid and paste soap, which have been developed in recent years have naturally increased in volume greatly. Certain by-products have likewise been made on a larger scale in later years. Such a product as

glycerin, for example, has more than doubled in volume since 1914.

As in other lines, however, packers in their soap-manufacturing operations have kept in step with modern trends, and, besides drawing on their animal fats for soap stock, are large users of the vegetable oils as raw materials, viz., palm, coconut, palm kernel, and olive oils, which are used in combination with tallow or with each other in the higher-grade soaps which have become popular for toilet use and in soap specialties. One cause of this present trend in raw materials used for soap is that vegetable-oil soaps lather better in warm water than an all-tallow soap which requires a very hot water to lather freely. Also vegetable-oil soaps are claimed to be more soothing and beneficial to the skin.

Soap is essentially a product of civilization, and in its present form is of comparatively modern origin. Jewish and Greek literature and the older records of Egypt and Assyria make no mention of a product corresponding to modern soap. True, the word "soap" is mentioned several times in the English Bible, but it is a result of incorrect translations from the Hebrew. In the ritualistic ablutions of ancient religions water alone is mentioned, although ointments and perfumes are also referred to. The Roman historian Pliny, in the first century A.D., ascribes the origin of soap to French and German tribes, and even writes of their use of hard and soft soap, which are the two main types today. However, it is likely that soap was first made by the Romans themselves. At any rate its use was widespread enough in the Roman world, for the ruins of a soap factory have been unearthed at Pompeii, where tradition has it that soap was first made and used.

On Sapo Hill, near Rome, according to some writers, on sacrificial and feast days fatted calves and lambs were sacrificed to Roman deities and burnt offerings were given to appease their wrath. The melted tallow from the slaughtered animals mingled with ashes from the burned wood. Rains, from time to time, packed this mixture of fat and ashes down into the soil, and some of it was washed down to the banks of a little stream at the foot of the hill. It was there that many of the women of Rome did their

laundering, and they found that because of the peculiar condition of the soil at the river bank, it was easier to cleanse the clothing. They learned that this soil from Sapo Hill, instead of making dirty hands more dirty, would, when used with water, remove accumulations of dirt and grease. Since only Sapo Hill soil had such strange properties, many Romans thought it had some divine power. Nevertheless, their curious inquiry and investigation of the cause of this cleansing property led them to discover the chemical combination of potash, from the ashes of the burned wood, with fat from the tallow of the animals that had been sacrificed. Potash dissolved in water forms a caustic solution which unites with the acids that are in fat, releasing glycerin and neutralizing them to form a new substance, soap. This dissolves readily in water, and when applied to the hands or clothing, lifts the dirt from them and holds it in suspension in the lather or suds that result.

The crude cleansing mixture manufactured by nature on Sapo Hill was very far from being pure, but it had cleansing power. Thinking men immediately began, therefore, to devise ways in which to improve that product of the soil which was then called "sapo." From this term the words "saponify" and "saponification" were later derived. The scientists long ago discovered that dirt was not necessary in producing saponification, and they began to make soap from animal fat, wood ashes, and water. The same quality of soap was used for all purposes, but the success varied with the kind of dirt to be removed. Most people could not understand the true action of soap. It was necessary for them to learn the process of a purely mechanical action, and to realize that its effectiveness was increased or decreased according to the minerals dissolved in the water, the type of dirt involved, and the proportions of free caustic or fat in the soap used.

Old and New Methods of Soap Making

For centuries soap making was a household art. People could not afford to buy soap, as a rule, until a few generations ago. Hence the old-fashioned country soap-making process in America

was a springtime operation. It was expected to utilize the fat and grease saved from cooking and the wood ashes collected from the household stoves and fireplaces during a long winter. An old cask with one head was selected. Numerous auger holes were bored in the head and the cask was then filled with alternate layers of straw and mixed lime and wood ashes. The cask was placed on a raised, slanting, grooved board. From time to time a pail of water was poured upon the contents of the cask, and eventually a brownish liquid began to emerge, which was collected in a pail and transferred to an iron pot. A chemical action had taken place which converted potash, the chief ingredient of the wood ashes, into caustic potash. The brownish liquid or lye was then boiled out-of-doors in an open iron pot over a fire, with the fat or grease, until the experienced eye of the soap maker considered the operation complete. The fire was then allowed to go out and the contents of the pot were left to chill to a solid mass, after which it was cut into bars of odd shapes, which were none too firm. The quality of the soap depended on the skill and luck of the operator, for these old-fashioned soap boilers were rule-of-thumb chemists.

Improvement in soap making was gradual until the early part of the nineteenth century, when a French chemist, Chevreul by name, determined the true chemical character and principles of fats. Thus he laid a firm scientific foundation on which the modern soap industry has been built. To this fundamental work of Chevreul must be added the great discovery of Le Blanc, who invented a cheap and satisfactory method of changing common salt into carbonate of soda or caustic soda, which could be substituted for potash, and thus gave the modern soap maker his basic material.

Today, the raw materials of the soap-making industry come from all lands and every clime. Of the animal oils used lard oil and tallow are important. Among the vegetable oils are palm, coconut, palm kernel, olive, corn, cottonseed, peanut, linseed, rapeseed, and sesame. The common animal fats are lard oil and tallow. Many industrial processes and phases of civilized life

afford by-products, or waste products, which are also of use in making cheap grades of soap for special purposes. Among these are skin dressing and tanning, bone-boiling and glue making, wool scouring, and the fatty extraction from garbage-utilization plants. Garbage grease is used by nearly all large soap manufacturers, and, contrary to the common belief, makes a very good soap. However, before it is saponified it is usually changed into fatty acid and distilled. The resulting distillate is very white and comparatively good in odor. As a matter of fact, the small soap manufacturer cannot use this as a source of his material, for the reason that he usually does not have a distillation plant in which to refine it. The artificially solidified fats of the modern chemical process called "hydrogenation" are also coming to be used in soap making.

In brief, the materials used in soap manufacture can be grouped under the following heads:

1. Animals fats and oils.
2. Vegetable oils and fats.
3. Saponifiers, e.g., alkalis such as potash and soda.
4. Fillers, e.g., alkali and salts such as sodium silicate, sodium carbonate and trisodium phosphate.

The soap industry, as a by-product of the packing business, has developed through chemical control. The first essential in producing high-quality soap is the selection of pure basic materials, and through chemical control the manufacturing processes are carefully supervised and regulated. During the manufacture of all soap, samples are sent every few hours to the laboratory for careful inspection, and very great care is taken to assure the proper control of processes, so that every cake of finished soap of any one kind is identical with every other cake of the same kind.

Pure soap is one of the products of the chemical reaction of certain kinds of alkalis upon one of the component parts of fat. Fats are composed of a combination of fatty acids with glycerin. Certain elements, such as potash, sodium, or lithium, water-slaked to form a caustic alkali, unite with fatty acids. The products of this reaction are soap, glycerin, and water. Further processing is necessary to eliminate all substances which are not pure

soap, although pure soap itself is a very effective cleaning agent, indeed the best and most effective cleaning agent in any water.

It is not necessary to add alkalis or builders in order to make the soap efficient. But low-costing alkalis or builders (which include soda ash, sal soda, lye, and trisodium phosphate) are employed to save soap and their main purpose, therefore, is not efficiency in use, but economy. A combination of soap and a builder, it is claimed, will perform as much work as an equal amount of soap by weight. While this economy feature overshadows the slightly better cleansing value of the soap, the fact is that the combination of soap and builder probably does not clean as well as an equal volume by weight of soap. The use of alkalis by laundries is for another reason than simple economy in the amount of soap. Too thick suds form a "cushion" of soap which prevents the soapy water from being forced through the fabric by the action of the paddle or mechanical wheel. While some laundries claim that alkalis help to whiten clothes, which in a laundry cannot be dried in sunlight, alkalis probably have little whitening value. Laundries declare the alkali does the whitening when it is really accomplished by a bleach which injures or weakens the fabric. Extremely hot water is used because it will hold more soap in solution, and the more soapy the water, the better it will clean. The heat, furthermore, probably causes activity which helps the mechanical action.

Regarding the term "pure" soap, there exists some confusion in the public mind. A pure soap to the consuming public is one which has pure ingredients. However, to the chemist it has a scientific meaning, viz., that a pure soap is a neutral soap in which the fats and alkali have been balanced exactly so that there is no free alkali to give an alkaline reaction or no free fat to give an acid reaction. Regardless of the fat used a pure soap is the result when alkali and fat are exactly balanced. Because the use of some fats gives more agreeable qualities to a soap and a capacity for more efficient cleaning, the average consumer thinks this is due to the soap being purer. Thus the popular confusion in thought has arisen.

In soap making at the present time there is an interesting competition between animal fats and oils, vegetable fats and oils, and fish oils as raw materials. The chief fats and oils competing with animal products are vegetable oils, but while the vegetable oils are the ones most significant, fish oils are almost as important in certain phases of the soap industry. Indeed, some soap manufacturers, other than national packers, use enormous quantities of fish oil. Some of these fish oils are soft and cannot be used directly in soap, but have to be hydrogenated, i.e., hardened and deodorized, before they can be processed into soap. One economic argument in favor of fish oils in certain kinds of soap is that there is not a great enough volume of animal fats and oils to supply the demand for soap, and if only animal fats were used, soap prices would be much higher and for many people, prohibitive.

Vegetable oils are used in soap making for different reasons, in the case of various kinds of oils. Therefore, it is necessary to consider each oil separately. For example, olive oil is used because it makes an exceptionally bland soap, pleasing in odor, smooth and unctuous, and noted for its mildness and medicinal properties. Coconut oil is used primarily in toilet and laundry soap to produce abundant lather. Suds obtained from coconut oil are voluminous and bubbles are large, but in general are thin compared to suds from straight tallow soap which is heavy and has small bubbles. For this reason it is used in the proportions of from 10 to 50 per cent in toilet and laundry soaps in order to improve the lathering power, especially in hard water. Pure coconut oil soap is made especially for use in regions where there is very hard water. It is also used as a salt-water soap, as it is practically the only soap which suds well under these conditions. Palm oil is used as a substitute for tallow when its price is low compared to tallow prices. Palm oil or fat is harder than tallow and makes a soap which lathers well, especially in commercial washing where high temperatures are used. Another important use is in the scouring of textiles.

However, palm or other vegetable oil, is not always a substi-

tute for animal fats, for some soaps require a high percentage of vegetable oils, and other soaps need a greater amount of animal fats and oils. For example, certain shredded laundry soap can be made either with mostly animal fats or vegetable, i.e., palm oil, in certain parts of the United States. Thus, palm oil is a competitor of tallow in soap making.

To sum up the use of animal and vegetable fats, and oils in soap, the fact is that for some kinds of soap, vegetable oils are preferable because of the properties desired in the soaps, while in many other cases animal fats are preferred. In still other soaps a mixture of vegetable and animal oils is preferable to the use of either type of oil or fat alone.

The chief animal fats and oils going into soap are tallow or beef fat or greases and hog fat. Each of these kinds of fat have several grades. For example, tallow may be choice, prime, No. 1 and No. 2; and greases may be "A" white, "B" white, yellow, and brown grease. While all of these are called fats in the trade, they are really oils because when processed for soap manufacture these fats are in a rendered condition and therefore they are liquid in form, i.e., they are oils.

The cleansing action of soap solutions is due mainly to their low surface tension, to their slippery, lubricating character, to the ease with which they form emulsions, and to their solvent properties. Because of their low surface tension, they wet readily and spread evenly over nearly every kind of surface. For the same reason, particles of dirt that have become detached and surrounded by films of soap solution show almost no tendency to unite or to adhere to surfaces being washed, and thus remain in the suds, or are carried away in the first rinse water. The mild alkalinity of soap solutions favors the formation of emulsions with all kinds of finely divided dirt. Some mechanical action is necessary in nearly every case, both as an aid in detaching dirt and in breaking it up into finer particles, which become surrounded by soap films and are thus held in a more or less emulsified condition. In brief, at least five factors play an important part in the cleansing action of a soap: (1) the presence in soap solutions of two products of hy-

drolysis: an acid soap and free alkali; (2) the power of emulsifying oily or greasy matter, which nearly always accompanies dirt and causes it to adhere to objects; (3) the formation of a foam or lather capable of entangling dirt particles; (4) the presence of colloids, and consequent formation of absorption compounds with dirt particles; (5) the solubility, in soap solutions, of the greasy matter accompanying dirt.

Hard Soaps and Soft Soaps

All soaps, scientifically speaking, are combinations of a mineral and a fatty acid. The base may be one of the alkali group, as potassium or sodium, in which case the resulting soap is soluble in water and possesses detergent, or dirt-removing, properties. It may also be of the earthy group, as calcium or magnesium, or of the heavy metal group, as iron, copper, or lead, when the resulting product is insoluble in water and cannot be used for cleansing properties. Soaps made with potash, and with soda lye from the same oils, are, respectively, soft soaps and hard soaps, according to their consistency.

The earliest soaps were soft soaps, but our forefathers soon learned to add common salt in excess of the amount of lye originally used. But this is not done today because, as soap is made now, such an addition of salt would "kill" the suds, and the soap would not lather in salt water. If, however, this addition of salt is made while the soap is still in a hot and somewhat dilute solution, a curd comes to the surface which forms a hard soap with lasting properties. The scientific explanation of this change is now known, viz., that the potassium, which was originally in combination with the fatty acids of the soap, exchanges places with the sodium of the common salt (which is sodium chloride). The result is that a soda soap is formed and comes to the top, while potassium chloride separates from the solution. The hard soaps are not hard because they are made from hard fats, but because their base is soda instead of potash. In the making of hard soaps, when natural animal or vegetable fats are used, one of the by-products of the reaction is glycerin, which is separated

and recovered in large quantities. In making soft soap, however, the glycerin is not removed, but remains in the finished product, which accounts in part for its softer consistency and its transparency.

There are differences in qualities or properties of soaps which are due entirely to the kind of fat or oil employed. All of the ordinary soaps of commerce are soda soaps, the potash soaps being used in the medical profession and, to a certain extent, in the "liquid soaps," the use of which is increasing in public washrooms not because of their greater sanitary value, but for the sake of economy because users often steal cake soap when available. Liquid soap is not more sanitary and is harder on the hands than cake soap. For soap is itself a disinfectant and kills any germs left on a bar of it. Hard soaps are represented by the laundry and toilet soaps; while soft soaps are represented by the liquid, soft, and semisoft pastes.

Boiled and Cold-Made Soaps

Broadly speaking, from the point of view of manufacture, soap is divided into two classes. One class, and probably the one most widely known, is called "boiled soap." In making boiled soap, the fat, the caustic or alkali, and the water are added in proper proportion and are thoroughly boiled under close supervision, after which the entire mass is allowed to settle. In the process of boiling, the glycerin becomes separated from the combination of fatty acids and alkalis and is drawn off and saved for commercial uses.

The other class of soap is known as "cold-made" or semiboiled soap. In its preparation the fats and alkalis are mixed together in their proper proportion, the saponification may take place without the assistance of heat, and all of the products of the combination of the chemicals remain intact in the soap. In such soap there is true soap, glycerin, water, and perhaps a small percentage of free fat or free alkali, i.e., alkali or fat that has not combined with any neutralizing agent.

A much greater proportion of soap is manufactured by the

BOILING SOAP STOCK IN TANKS BY STEAM

DRYING SOAP IN FLAKE FORM

process which involves boiling. Raw material is much more easily controlled in the manufacture of boiled soap than in the manufacture of cold-made soap, and as a result a much more neutral soap is produced. True, the recovery of glycerin from the fat is quite a factor, and where large quantities of soap are made, the glycerin that is saved has considerable value. Its value as a by-product of soap making enables the manufacturer to sell the primary product, soap, at a lower cost than he could if the glycerin were not recovered.

Typical Soap Making

In general, there are several methods of making soap. A description of the one most commonly used will give a good idea of the chemistry involved. The fat in melted condition is pumped into the "kettle" or "soap pan," where it is boiled up with open steam, which serves both to heat and to agitate. The pans are frequently large enough to hold 1,000,000 lb. of soap. The practice of heating the pans by fire has been discontinued in all modern factories, and they are now provided with open steam jets that discharge into the soap the water of condensation, which is very helpful in saponification. They are also equipped with large closed steam coils, the condensed water from which is conducted away from the pans. Steam heating gives the soap-boiler perfect control through steam valves.

During saponification, the contents of the pan are kept boiling to promote chemical action and thorough mixing. The lye, consisting of a 10–20 per cent solution of caustic soda, is run rapidly, so that a large excess of uncombined alkali is avoided at any time. The saponification proceeds smoothly almost as fast as the lye can be run into the pan. It is easy for the operator to tell if the alkali is being taken up; and toward the end of the process the lye is run in more slowly. After there is an excess of lye present, the soap is thoroughly boiled up to insure complete saponification. The soap is then grained by the addition of salt, or better, strong salt solution. Soap is almost insoluble in either strong caustic soda or strong salt solution, and an addition of

sufficient of either of these grains it so that it separates in large insoluble curds. The boiling is now continued by means of the closed steam coil. Any impurities that may have been present in the fat are largely destroyed by this boiling with caustic soda. The glycerol formed by the saponification goes into solution in the lye, and should any fat have escaped saponification up to this time, it is converted into soap during this boiling.

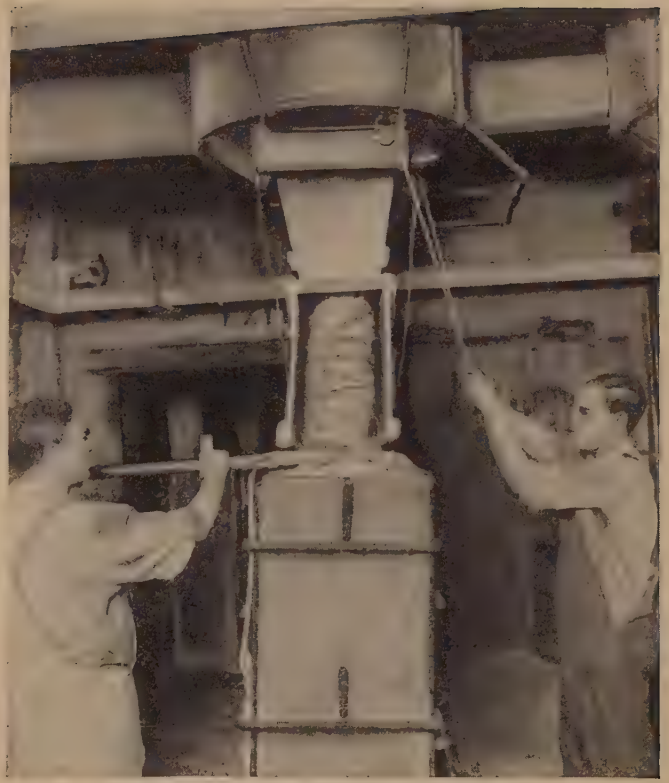
When the steam is turned off, the lye layer, containing most of the excess alkali, slat, and glycerol, and being heavier than the soap, settles to the bottom of the pan and is removed. This is boiled with fresh stock, and in this way the excess alkali is not lost, but is used in making more soap. The spent lye is then sent to the glycerol department for the recovery of glycerol.

The soap left in the pan is boiled up with fresh caustic soda or fresh lye, and further lyes are removed, the objects attained being the complete removal of soluble or destructible impurities, the separation of insoluble impurities, the more thorough recovery of glycerol, and the insuring of complete saponification. The practice may vary in details without affecting the principles involved.

After the final lye is removed from the pan, water is run in slowly while the soap is boiled up with open steam. The effect of this procedure is gradually to dilute the lye surrounding the soap curds until the solubility of soap in it becomes greater and greater. At the same time the soap curds take up a little more water and become very thin in consistency. The contents of the pan at this point still consist of a "two-phase system," a lye phase diluted to the point where it contains an appreciable amount of dissolved soap in addition to nearly all of the salt, glycerol, and excess alkali still present, and a soap phase which consists of almost pure soap containing a very small amount of dissolved salt and alkali. It is important not to add too much water during the settling operation, for this would cause the two phases to merge into one and permit of no separation of pure soap from the salt and alkali.

When the right point is reached the soap has attained its minimum viscosity; therefore the steam is shut off, and a rapid separation of the two phases into distinct layers is brought about. This

CUTTING LAUNDRY SOAP INTO BARS



SOAP COMING FROM BOILING KETTLE

separation can be produced at once in a centrifuge, or by gravity on standing. The upper layer consists of an almost perfectly pure settled soap containing about 30 per cent of water; and the lower diluted lye layer, known as "nigre," contains practically all the impurities, as salt and alkali, and about one-fifth of the soap in solution. Each of these phases is absolutely homogeneous throughout, except for local influences, and there are but two phases of this stage, notwithstanding a common belief that there is also a lye layer that is practically free from dissolved soap. During the time that is necessary for gravity settling, the contents of the pan become somewhat cooled, and the nigre, or lower phase, which separated them when hot suffers a change due to the cooling, the solvent properties of the dilute lye becoming less. This brings about a separation of some of the soap of the nigre from the cooled lye, a small amount of which then settles to the bottom of the pan, giving rise to the belief that the settling involves a third clear-lye phase.

Classes of Boiled Soaps

When soap is kept hot it is in a liquid state, and the pure liquid settled soap may be pumped off and sent through pipes to any part of the factory. This is a great saving in labor over what would be required to dip the soap out, or move it about by other means.

Boiled soaps can be divided into the following types, viz., framed soaps, milled soaps and flake, chip, powder, and other varieties. In the manufacture of framed soaps, the hot soap from the kettle is pumped first into crutchers (mixers), where any "filler," perfume, etc., are added, and then into frames, which are rectangular boxes in which soap is allowed to cool. After cooling, the sides of the frames are removed, and the soap is first cut into slabs and then into bars. Finally, it is stamped, wrapped, and packaged for the trade. As a rule, the moisture content runs about 30 per cent. Bar laundry soaps and floating soaps belong to this class. Floating soaps are crutched, or mixed, so that many minute air bubbles are incorporated into the soap, lowering its density sufficiently to cause the resultant product to float in water.

Milled soaps are processed as follows: The hot soap from the

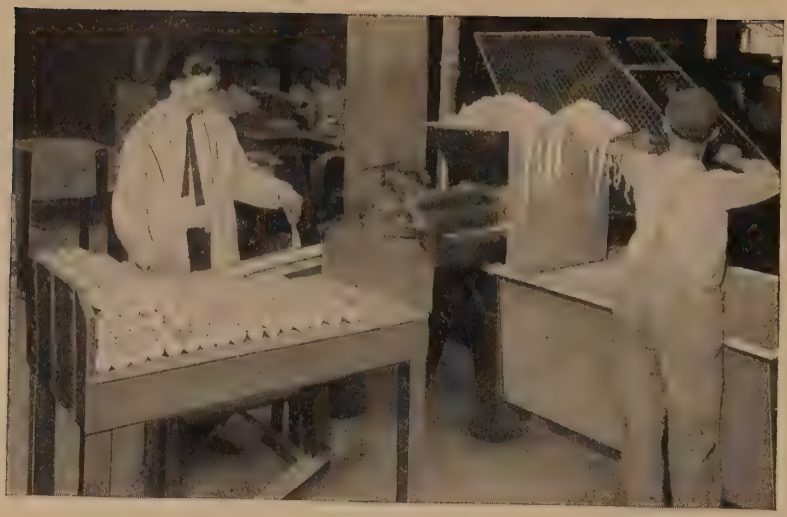
kettle is led onto a cooled cylinder, or roll, which revolves, and from which the soap is scraped off in the form of a chip, or ribbon. This passes through a dryer, where the moisture content is lowered from 30 per cent to about 10 per cent. Perfumes are added to these flakes, which pass through several sets of rollers, the added ingredients being thoroughly incorporated or mixed into the chips. From these rollers the soap passes into a plodder, which presses or molds it into long bars that are cut into smaller bars, stamped, wrapped, and packed. Toilet soaps are usually prepared for market by this method.

Chips, flakes, powder, and other washing preparations go through the same system of manufacture as the milled soap, up to the rollers. In short, the dryer delivers them in flake form ready for the market. Powdered soap is made from chips by further reducing the moisture content and grinding.

Toilet soap is now usually manufactured by the settled-soap process, subjecting the soap base thus obtained to drying, and machining it into cakes of suitable size and shape. The pure settled soap is run onto large hollow steel rolls that are cooled by water. It is chilled to a solid film by passing through a succession of these rolls of varying speeds, the soap film always adhering to the faster roll. It is cut off into ribbons, which fall upon endless wire belts and are thus carried through a drying chamber provided with a strong circulation of warm dry air. In this way the soap is dried until only about 8–12 per cent of moisture remains, as compared with the 30 per cent originally present in the settled soap and left in most floating and laundry-bar soaps, since the rapid drying of these latter in bar form is not an easy matter.

The dried soap ribbons are mixed with some perfume material, are run through large roll mills to make the mass thoroughly homogeneous, and are then squeezed in powerful screw machines, called plodders, until a solid mass is obtained. This is forced by great pressure to flow through a suitable nozzle, is cut off into pieces of the desired weight, pressed into cakes, and wrapped. The bulk of such work is done by machinery.

Most laundry and toilet soaps are perfumed. This is done pri-



PRESSING SOAP STOCK INTO ROLLS

PRESSING TOILET SOAP INTO CAKES

marily to make them more agreeable in use, although the perfume materials also exert a little preservative sweetening effect, preventing or delaying rancidity. The perfume materials are derived from flowers and plants by steam distillation or extraction and from synthetic chemicals. Many of the ingredients used in perfuming soap are like those employed in flavoring candy.

There is a soap to suit every kind of skin, just as there are glasses to fit every kind of eyes that need them, and shoes to fit feet of varying and various shapes. For that reason a discussion of the composition of soaps, in addition to an analysis of the true soap stock, is of interest.

Alkalis are added to soaps for sake of economy: for instance, laundry soaps nearly always contain excess alkali. Some claim that this is done to make the soap suitable for use in hard water, and help it carry off free grease or fat from materials which are to be washed by it. Of course, no one would think of using a strong laundry soap for washing highly polished woodwork surfaces, or the hands and face, the alkali being entirely too harsh for such use. In toilet soaps the free alkali should be practically absent. Even a trace of free fat is objectionable as it might lead to rancidity. If such soaps are filled, which can be only for cheapening purposes, it is usually done with talc, starch, or some such inert material.

Cold-Made or Semiboiled Soaps

The cold-made process is mostly utilized when some vegetable oils, such as coconut oil, are used in substitution for animal fat. The neutral quality of a boiled soap is more easily controlled, and consequently it is easier to manufacture neutral soaps by the boiling process. It is harder to salt out a coconut-oil soap than a soap made from tallow and some other vegetable oils, and hence it is more difficult to separate the glycerin.

In manufacturing cold-made or semiboiled soap, the melted fat is run into the crutcher together with the exact amount of alkali (soda or potash) necessary to saponify. The mixture is stirred by means of a propeller until a permanent homogeneous emulsion is formed. Little or no heat is applied, since the heat of the reac-

tion is usually sufficient to complete saponification, once a good emulsion is formed. The "mix" is run into frames and allowed to stand in a warm place until the saponification has progressed as far as possible. The sides of the frames are then removed and the soap is cut into bar form, is stamped, and wrapped. This type of soap usually contains about 5 per cent free fat, i.e., unsaponified fat, and also all the glycerin resulting from the saponification.

Semiboiled soap is made by the same process as the "cold-made" soaps described above, except that heat is applied (by means of a steam jacket surrounding the crutcher, or by steam coils) until saponification is complete. Here again the resulting glycerin remains in the soap. This type of soap is usually a liquid, paste, or semipaste, and is usually run into barrels or similar containers for shipment. Liquid soaps are made by this process.

For many purposes the efficiency of soaps is increased by the addition of so-called "fillers." These fillers for soap are of two classes: "alkaline salts" and "inert fillers." Active alkaline salts often employed are soda, ash, sal soda, trisodium phosphate, etc. These are added because they act as water softeners and also as detergents, or dirt removers. Inert fillers may be talc, starch, clay, etc., which usually have no value except to create bulk. Inert fillers are not used in soaps made by leading manufacturers.

Miscellaneous Soaps

Floating soaps are usually boiled soaps which have not been milled. After coming from the kettle they have been thoroughly churned or crutched until enough air has been incorporated to make them lighter than water. They are usually pure soaps, though not more pure than non-floating soaps, but carry considerably more moisture than milled soaps, or between 25 and 30 per cent.

Potash soaps are the soft or oil soaps, and are made by the semiboiled process, since it is practically an impossibility to separate the soap and glycerin lyes in them. They are of interest more for medical use; that is, the official green soaps, and for polished woodwork surfaces or delicate fabrics. If they are properly made,

potash soaps can be made neutral so as to have no alkali action when used; and the potash soap, although more expensive, perhaps leaves fabrics, or surfaces washed with it, in a less harsh condition than a soda soap. The nature of a soft soap and the method of manufacture adopted leave these soaps with nearly 50 per cent of water.

Resin is made from the sap of the pine tree. In the southern states the pine trees are tapped in the early spring and the sap gathered. The sap is then distilled. This process extracts the turpentine that is in it, and leaves a residue which is resin. The resin, while in this liquid state, is run into barrels in which it hardens into a solid transparent mass. The first run of resin is light yellow in color, but grows darker the longer it runs, the last being almost black. Resin is acid in nature, and it can be used to unite caustic alkalis, as described under alkalis, to form the resin salt or resin soap. This soap, properly compounded with tallow soaps, is a useful detergent.

Miscellaneous soaps include quite a number of varieties. "Cleanser" is usually a mixture of soap, alkaline salts, and a mineral abrasive—the purpose of the latter obviously being to give a cutting or polishing action. Washing powder is a mixture of pulverized soap with a relatively large amount of filler, usually soda ash. Dry-cleaning soaps are entirely different compositions from any of the ordinary soaps. Essentially, they are partially saponified lime soaps dispersed in organic solvents, with sometimes small quantities of soda or potash soaps added. They differ from the ordinary soaps in that they are insoluble in water, but are soluble in gasoline, benzine, naphtha, etc. Hence their use is confined to the dry-cleaning industry. Some of these soaps are soluble only in hot solvents; but others, such as are used as brushing soap for bench work, are soluble in cold solvents.

Glycerin

The economic manufacture of soap depends largely upon the recovery of glycerin as a by-product. Hence the more free fatty acids present, the less valuable the oil. Glycerin is in the form of

a syrupy red liquid which is liberated from the fats and oils and goes to the bottom of the kettle during the soap-making process. It is purified by distillation into the commercial form. Glycerin is used by the medical profession as a vehicle for certain medicines to be applied externally. A new use which is becoming popular is as an anti-freeze protection for automobiles. Radiator glycerin can be placed in a brine solution capable of reducing its temperature to $-30°$ F., or lower without freezing. For its ability to resist low temperatures radiator glycerin was used in the Norge flight over the North Pole. It is also used in the manufacture of nitroglycerin and other powerful explosives.

In more detail, the method of glycerol recovery is as follows: The various spent lyes recovered from the soap pan are treated for the recovery of the excess alkali they contain, and then treated with a salt, such as ferric chloride or aluminum sulphate, which form insoluble soaps. In this way any soap remaining dissolved in the spent lye is precipitated as an insoluble soap and is removed by filtration. These insoluble soaps, being gelatinous in nature, form coagulants which inclose other suspended impurities, thus aiding complete clarification. The lye, now neutral and clear, is evaporated in large multiple-effect evaporators under reduced pressure. Salt crystallizes out, is separated from the concentrated glycerol lye, and removed to the soap department to be used to salt out soap again. By further concentration a glycerin is obtained which contains approximately 80 per cent glycerol. This is subjected to distillation with steam in vacuum stills and yields the so-called "dynamite glycerin" of commerce, from which nitroglycerin is made. Further distillations produce a very high-grade glycerol, the "C.P. glycerin" of commerce.

One hundred pounds of any of the common fats, when pure and neutral, will give theoretically ten pounds or more of glycerol. The best practice approximates the theoretical yield.

CHAPTER VII

PHARMACEUTICALS

The pharmaceutical by-products of the packing industry are vitally related to the physical and mental welfare of all human beings, since they are finding ever increasing use in the field of medicine. Their production is of comparatively recent development, and has come about as the direct result of scientific research and chemical control. Both animals and human beings possess a number of glands, some of them ductless, which exercise a great influence on the body processes by reason of their external and internal secretions. In the case of human beings, the more obvious organs and functions of the body were known long ago. For example, physicians understood, even before the Christian era, the part played by the stomach, the intestines, and the lungs. However, certain organs which seemed unconnected with the known body processes were discovered from time to time, although their functions could not be determined. The greatest obstacle to progress in the medical knowledge of many of these mysterious glands was the belief that every useful organ of the body must have a definite entrance or exit, as, for example, the gall duct, which empties into the intestines.

For purposes of classification a large number of these glands are called ductless, internally secreting, or endocrine glands. The situation of these glands is not localized in groups, but instead they are scattered through various parts of the body. For instance, in the brain cavity there is a gland known as the pineal body, and near it the pituitary gland. In the throat, astride the Adam's apple, is the thyroid. In infancy and childhood there is an important gland called the thymus, situated somewhat below the thyroid and above the heart. Just over the kidneys are the suprarenals, which are as frequently called the adrenals. Other glands are the sexual organs, the testes, and the ovaries, which

manifest profound influences on the characteristics of the human organism.

Each of the endocrine glands secretes substances exercising a particular effect upon the functioning of the body. The secretions from these glands pass directly into the blood stream and regulate the metabolism, i.e., the internal activities and the building-up and tearing-down processes of the body. For want of a better term, products of these glands are known as internal secretions. The effect of each internally secreting gland varies from the normal in the direction either of oversecretion or undersecretion. A typical gland having a duct and producing external secretions, may also possess the additional function of internal secretion. An example of such a gland is the testis, or ovary. The rather recently acquired knowledge of internal secretions from glands, both in human beings and in animals, e.g., hogs, cattle, and sheep, has had far-reaching effect, both in physiology and pathology. We have learned that the body conditions and metabolic relations we recognize as normal depend on delicate interadjustments between these secretions, and that change in these interadjustments produces effects which we readily recognize as pathological. Through endocrinology, medical science has come to understand certain diseases much more clearly and to prescribe remedies for them. It may be questioned if there is a single branch of medical art that has remained uninfluenced by the discovery of the functions of endocrine organs. As evidence of this progress it may be noted that never before have there been so many investigators, chemists, biologists, pathologists, and clinicians engaged in one phase or another of this field. Already the usual output of special articles numbers three thousand yearly.

The blood, during its course through a gland, e.g., the thyroid, takes from it some of its secretion, thereby helping to preserve the normal equilibrium of the body processes. If any of these glands fail in secretion it is usually possible to make up the deficiency by feeding or injecting extracts of that particular gland. Extracts of ductless glands may be administered either to supplement deficiencies of secretion or to offset hyper-secretions of other glands.

Influence of Internal Secretions

The control exercised by internal secretions from various glands upon the development and body processes of men and animals presents a fascinating study. While investigation has revealed only a portion of the total effect of this control, certain rather definite principles have been established. In a general way it is clear that these internal secretions govern in some measure the orderliness of human life, and the conduct and character of the individual. For example, the stature, type of face, shape of head, length of arms and legs, shape of the pelvis, quantity and formation of fat, amount and distribution of hair on the body, health and tension of the muscles, tone of the voice, and emotional expression are all largely determined by the flow of internal secretions.

There are many instances from history which might be cited to show how one gland or another, when unduly enlarged or dominant, has possessed an influence upon the individual of an altogether abnormal character. The dominance of one gland or another has much to do with the creation of particular types of personality, e.g., the thyroid-centered types, the pituitary-centered types, and the adrenal-centered types. For example, Caesar and Napoleon were pituitary-centered. Traits due to internal secretions are, in general, heritable, and the evolution of their functions can be detected throughout the different phylla and genera of animals. Paralleling other traits of temperament and character, due to internal secretions, are certain disease tendencies and diseases themselves.

Modern research has attempted to isolate the active principles of the endocrine secretions, both for the purpose of identification and, where possible, to aid in synthetic production. Several of these principles have been isolated chemically, while quite a number are recognized by their effects. These active principles are known as hormones, and apparently possess functions of energizers, catalyzers, and stimulants or inhibitors of various sorts. Several authorities have pointed to the analogy between hormones and those minute substances known as vitamins, which in recent

years have been found to exercise comparable functions in the nutrition of the body. Besides minuteness of the amounts required, there are many similarities between the physiological properties of these vitamins and those of hormones. Indeed, vitamins may be hormones of extraneous origin.

A striking characteristic of these products of internal secretion is their potency; even in microscopic quantities they produce effects. In some cases the physiological reaction from a given dose of the hormone, as in the case of that from the medulla of the suprarenal capsule, follows immediately upon its administration. In other instances the bodily response, as in the case of the thyroid principle and of the internal secretion of the sex glands, is much slower. It often requires years for the full development of the results of their increased or diminished action, as is well seen in gigantism which is hyperpituitary; goiter; hypothyroid; and castration—all instances in which there is either an excessive or a diminished output of the hormone concerned.

In almost all cases of hormone action it is necessary to consider not merely the hormone itself, but also the functional state of the organ or organs which are to be affected. For example, it has been suggested that the reason the hands and feet during the development of the disease known as acromegaly, respond so easily and disproportionately to the increased hormone flow from the anterior lobe of the pituitary lies in the fact that the hands and feet are in more constant use, and therefore respond more vigorously to this sensitizing growth hormone. This is only an exaggerated manifestation of the normal process, and is due to the flooding of the organ with this hormone. Hard manual labor will normally itself produce marked growth responses in the hands and feet, but this response never approximates that seen in acromegaly.

Hormones mutually influence each other's actions, either in augmentation or inhibition, when administered in an appropriate manner. For example, when thyroid extract is injected, or when the thyroid gland in the living animal is induced by electrical stimulation to pour an excess of its hormone into the blood stream,

a subsequent injection of epinephrin prepared from the suprarenal glands will induce a very much greater and more prolonged rise of blood pressure than is seen under normal conditions.

Interrelationship of Gland Functions

Since the glands of internal secretion are functionally associated with each other, and since their harmonious operation tends toward equilibrium of the nervous and metabolic processes, health becomes the result of the action and balanced interrelation of the specific products of hormones of the endocrine organs. One of the most fundamental phases of the subject is this physiological interaction of the endocrine organs. Every week new discoveries are bringing more actual proof of this. It is in this field that the recent advances in our knowledge of the ductless glands are most striking. More especially when removal of one of the endocrine organs takes place in the prepubertal stage do marked alterations occur in one or more, generally several, of the remaining glands of this class. Among the remote consequences of these alterations there may then be distinct changes in the body conformation. For example, it has long been known that during pregnancy the anterior lobe of the pituitary is abnormally large, and that pregnancy and lactation cause enlargement of the thyroid gland. Recent research has made it clear that the thyroid gland, the pituitary, the adrenals, and the pineal gland stand in functional relationship with the sex glands, and are consequently in a position to exert an influence on the secondary sex characteristics. This relationship is mutual in character, for it is found that the growth of the sexual glands themselves depends upon the state of development of the other endocrine organs.

It is only in consequence of the modern detailed study of these products of internal secretion that such striking correlations have been established between them and certain structural changes occuring either in the embryonic or adult state. A case in point is the manner in which all the tissues of the hand, the bones, blood vessels, muscles, connective tissue, etc., become enlarged in unison under the influence of a sensitizing hormone derived from the an-

terior lobe of the pituitary. In fact, it is well established that, given an adequate diet, the growth and development of perhaps all the structures of the body are dependent upon the internal secretions. In the absence of the necessary hormones, these structures cannot remain normal, but atrophy or waste away. The maintenance of the normal condition is dependent upon a continuous, if only infinitesimal, supply of a particular hormone.

TABLE XVIII

CHIEF GLANDS OF INTERNAL SECRETIONS

Name	Secretion	Function
1. Thyroid	Thyroxin	Gland of energy production; controller of growth of specialized organs and tissues—brain and sex
2. Pituitary		Gland of energy consumption and utilization—continued effort
Anterior	Unknown	Growth of skeleton and supporting tissues
Posterior	Unknown	Nerve cell and involuntary muscle cell, brain, and sex tone
3. Adrenals		The gland of combat
Cortex	Unknown	Brain growth—tone development of sex glands
Medulla	Epinephrin	Energy for emergency situations
4. Pineal	Unknown	*a*) Brain and sex development *b*) Adolescence and puberty *c*) Height and maturity
5. Thymus	Unknown	Gland of childhood
6. *a*) Testes (male) / Ovaries (female)		Glands of secondary sex traits
b) Corpus Luteum		Regulator of mammary and uterine functions
7. Parathyroids		*a*) Controllers of lime metabolism *b*) Excitability and muscle and nerve
8. Pancreas	Insulin	Controller of sugar metabolism

No better example of such a dependence can be found than that existing between the ovary and the uterus. Removal of the former is inevitably followed by decrease in size and loss of normal functions of the latter. The fact is explainable on no other assumption than that a hormone secreted by the ovary is carried to the uterus, the tissues of which are in some way affected by it, so that it grows to full size and maintains it throughout the period of sexual activity.

Table XVIII shows the chief endocrine glands used for clinical administration, the name of the hormone or secretion involved, and the function.

Why Packers Prepare Gland Extracts

During the last thirty years certain units of the packing industry have been increasing the preparation of extracts from the glands of cattle, hogs, and sheep. This extension of activities into

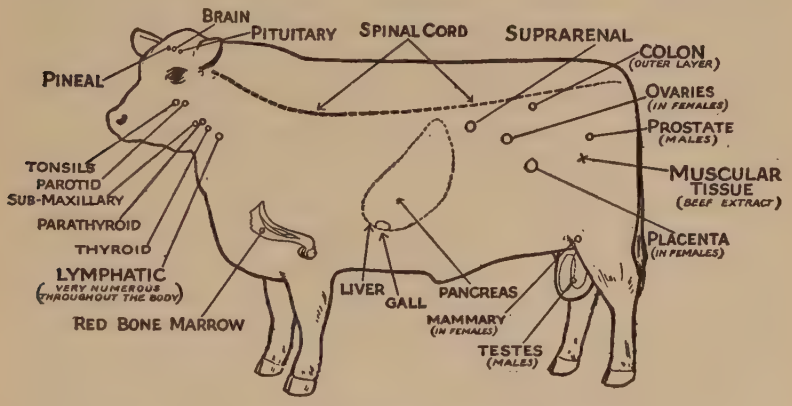


Fig. 33.—Sources of medicinal products from cattle

a by-product field somewhat remote from the main task of supplying meat-food products was a very natural evolution. After medical research had determined that deficiencies in human glands could be remedied by controlled administration of gland extracts, the demand for them became so great that the only adequate source of supply was in the packing industry, where large numbers of animals were daily killed under sanitary conditions, and a sufficient amount of each glandular tissue could be preserved to insure preparation of pharmaceutical products on a commercial scale. With such factory methods, and under skilled chemical control, it was possible to insure standardization and high quality.

At the present time there are probably a hundred pharmaceutical products prepared in packing-house laboratories. However, this number includes some which are not strictly endocrinal in

origin, i.e., pepsin, rennet, benzoinated lard, etc. The number of glands from which the pharmaceuticals are made is about twenty, but the number of products prepared from these glands is in the neighborhood of forty-eight. As an example of the volume of slaughter necessary to make the manufacture of glandular extract possible, the pituitary glands from twelve thousand young cattle are required to produce a single pound of desiccated posterior pituitary substance. The preparation of these pharmaceuticals requires laboratories provided with a variety of equipment, including automatic temperature regulators and vacuum drying ovens. All glands are carefully selected and examined before treatment, and those showing any signs of atrophy or other abnormality are discarded. Temperature, humidity, and other factors affecting drying and decomposition are carefully regulated in order to preserve completely the enzymes, hormones, or other active secretions of the glands. All pharmaceutical products which contain known enzymes and active principles are standardized to insure uniformity of dose and dependable results. The finished preparations are accurately tested by chemists trained in physiology and bacteriology.

Gland Extracts' Use Only by Medical Advice

Although the theory involved in the use of extracts of ductless glands is very simple, the actual use of these glands in medicine is quite complicated. This is due to the powerful effect which most of the glandular extracts produce, and the extreme delicacy of the interadjustments of the bodily functions. It is strongly advisable, therefore, that these extracts never be used except under medical direction. Indeed, immeasurable harm to human health has been occasioned in recent years by the ill-advised use of thyroid extracts, for example, to counteract obesity or to secure reductions to fashionable bodily contours.

The use of thyroid extract without medical and clinical observation is very likely to lead to unstable pulse and palpitation of the heart. If unsupervised use is made of desiccated suprarenals, the blood pressure becomes too high, and a condition toxic to the

stomach results, causing vomiting and other derangements. Overdoses of pituitary substance likewise cause violent upsetting of the internal digestive organs. For these reasons pharmaceutical products manufactured in the packing industry are never distributed among ultimate individual consumers, but only through the recognized and authoritative medical channels, such as reputable physicians and licensed pharmacists.

The Chief Endocrine Glands

The thyroid.—Of the glands used in pharmaceutical manufacture, one of the most important and interesting is the thyroid. This gland consists of two maroon-colored masses on either side of the windpipe and close to the larynx. These masses are bridged by a narrow isthmus of the same tissue. In human beings the thyroid gland has always attracted much attention because its enlargements constitute the prominent deformity known as goiter. The internal secretion of the thyroid has a definite controlling effect upon the pulse rate and the blood pressure, the skin and its hairiness, the moisture and amount of mucus, the growth and size of the bones, especially in the hands, feet, and skull, and finally upon the intelligence, through its effect on the convolutions of the brain. The significant fact about the chemical composition of the thyroid secretion is its relatively high percentage of iodine. Indeed, this secretion depends for its activity upon a sufficient supply of iodine being absorbed from the food.

The thyroid gland is the controller of the speed of living. This speed of living is the rate at which the chemical reactions that constitute the process of life go on in the body. When the reactions accelerate, more oxygen and good material are used, more energy is liberated, the metabolic processes occur more rapidly, and the individual feels, thinks, and acts more quickly. The thyroid may be compared in this matter to the accelerator of an automobile.

Some human beings have such insufficient thyroid secretion that they are dwarfs of a peculiar type, known as cretins. In other cases, insufficient thyroid secretion brings on certain lymphatic swellings, known as myxoedema. On the contrary, too much thy-

roid secretion in the blood and tissue causes nervousness, insomnia, tachycardia, loss of weight, digestive disturbances, and kindred disorders. One of the recently discovered uses of thyroid extract is in the treatment of cataract in elderly people. Senile cataract is supposed to occur when there is a general breakdown of the body forces, and the administration of thyroid extract has a tonic effect on the general system. Present indications are that the improved vision resulting is only part of the general tonic effect, but

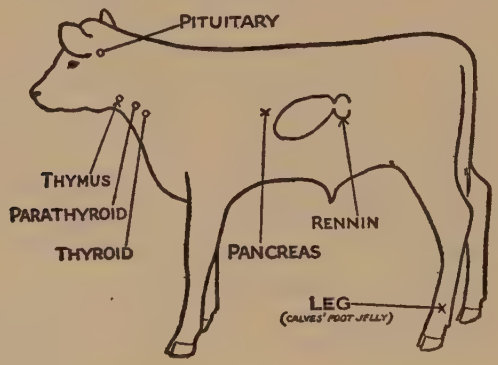


FIG. 34.—Sources of medicinal products from calves

it provides a new weapon of attack against this insidious form of blindness. Stunted thyroids not only lead to idiocy and dwarfishness, but apparently limit the secretion of milk in nursing mothers in such a way as to induce symptoms of thyroid deficiency in the offspring. Thyroid deficiency also slows the rate of growth.

The thyroid is perhaps the most variable organ in the body, and responds, by changes in size and functional activities, to the changes in both external and internal environment.

THE PARATHYROIDS.—Near the thyroids in both animals and men are four tiny glands known as the parathyroids. These are sometimes imbedded within the substance of the thyroid in the neck, and sometimes directly behind it, upon the windpipe. As a rule these parathyroids are only about the size of a wheat seed. However, they are separate individual glands with a structure

and function of their own, and have a definite influence upon the work of the body. For example, if they are removed an animal's excitability is increased from five hundred to a thousand times. The chief function of the parathyroids is to regulate the amount of lime in the blood and cells. In the making of bone and teeth lime is a very important factor. The parathyroids affect the rate of coagulation of the blood, an especially significant factor in wounds, and maintain the tone of the nerves. In human beings the nervous overexcitability from loss of parathyroid secretion is called tetany. To maintain a normal steadiness of muscle and nerves, the parathyroid glands are essential.

PITUITARY GLAND.—At the base of the brain there occurs a lump of tissue about the size of a pea, weighing only 0.6 gram, of a grayish yellow color and insignificant in appearance, known as the pituitary gland. As a matter of fact, the pituitary is really two glands in one. Each part is distinct in origin, history, functions, and secretions. To distinguish them, they are referred to as the anterior lobe and the posterior lobe. From the posterior parts of the pituitary, an active substance has been discovered which is of great use in medical science. The internal secretion from the posterior lobe has many remarkable functions. It controls the tone of the tissues and the muscle fibers of the blood vessels. It also regulates the contractile organs of the body, such as the intestines, the bladder, and the uterus. The vital importance of the pituitary gland is indicated by its remarkably protected position, its extraordinary persistence, and its abundant blood supply. No other gland of internal secretion provides an adequate substitute for it.

Both the thyroid and the pituitary control growth, and also the differentiation, the mass, and intricacy of the tissues. But they differ in the site of their control. The thyroid affects directly the inner and outer coverings of the body, the skin, the skin glands, the hair, the mucous membranes, and the irritability, or the preparedness for response, of the nerves. The pituitary acts more upon the framework of the body, the skeleton, and the mechanical supports and movers. Bone and ligament, muscle and tendon, seem to be within its immediate sway. The secretions of the pitui-

tary gland diffuse directly into the fluid bathing the nervous system, supplying beneficent stimulants and aiding in the elimination of waste. While the thyroid raises the energy level of the brain and the whole nervous system, as a by-product of its general awakening effect upon all cells of the body, the pituitary probably stimulates the brain cells more directly, in a manner similar to mild doses of caffeine or cocaine.

The difference between the thyroid gland and the pituitary may be expressed in this way: while the thyroid increases energy evolution and so makes available a greater supply of crude energy by speeding up cellular processes, the pituitary assists in energy transformation, in energy expenditure and conversion, especially of the brain and the sexual system. In short, the thyroid facilitates energy production; the pituitary, its consumption. The pituitary appears, therefore, as the gland of continued effort. Hence, fatigability or general inability to maintain efforts are one of the prominent complaints when there is destruction or an insufficiency of pituitary substance.

THE ADRENAL OR SUPRARENAL GLANDS.—There are two adrenal or suprarenal glands. Each one of them is shaped like a cocked hat, lying astride the kidneys, and is easily recognized by its yellowish fatty color. In common with some other glands, the adrenals are relatively larger and more prominent in children and young people than in adults. Compared with their size, the amount of blood passing through them is very great. Each gland is composed of two parts, the cortex (literally the bark), or outer portion, and the medulla (literally the marrow), or inner portion. While they are not separated by any clean-cut line, as strands of tissue from one penetrate into the other, there is a great difference in their chemistry and function. The medulla contains numerous nerve cells belonging to the vegetative system, and its secretion is known as epinephrin.

The importance of the adrenals in life processes is such that an extract from them, when injected into a vein, produces an unusual, although temporary, rise of blood pressure. It also withdraws the blood from the digestive and other internal systems and con-

centrates it in the brain and muscular tissues. Because this condition is essential in any emergency strain or extraordinary physical effort, the adrenals are known as the glands of combat. This influence is remarkable when it is realized that the concentration of epinephrin in the blood is only about one part in twenty million, with about one hundred-thousand times this much stored in the gland itself. The amount of it in the blood varies with muscular exertion and profound emotion, such as pain, fear, and rage, which increase the drain upon the supply of this secretion. With its entry into the blood there is a tremendous heightening of the tone of the nervous and muscular system. The adrenals play an important part in the production of body heat. In modern life they are called upon to function to a greater extent than in the past. While savages and barbarians had just as many emergencies and shocks to overcome as we have, the inhibitions arising from education and conditions of modern living, with improper food, sedentary indoor confinement, and the noise in greater cities, are undoubtedly making greater demands upon our adrenal glands. When these demands become too great in any particular case there ensues an insufficiency of adrenal secretion, resulting in nervous breakdown—a not uncommon occurrence among American business men—and, in some cases, melancholia and suicide.

THE PINEAL GLAND.—The pineal gland is a cone-shaped bit of tissue hidden away at the base of the brain in a tiny case behind and above its larger neighbor, the pituitary. In part, the pineal gland is made up of nerve cells containing a pigment present in the retina of the eyes. This favors the argument that the ancient function of the pineal was as an eye. For a long time it was thought that the pineal had no function for modern man, but research has shown that it distinctly regulates childhood growth. It has an indirect influence, hastening or retarding puberty and maturity, which is the result of an excess, or deficient, secretion. Pineal substance and many other standardized pharmaceuticals can only be made where there are perfect refrigerative facilities, for some fifteen thousand of the glands are required to produce one pound of the drug.

THE THYMUS.—The thymus is situated in the chest, on both sides of the windpipe, covering the upper portion of the heart. It is a grayish yellow mass which, when cut, presents the spongy structure of sweetbreads (pancreas). In function the thymus dominates childhood by inhibiting the activity of the sex glands, rising and declining as children grow up. The size and condition of the thymus is an index of the state of nutrition of the body. For example, underfeeding for a period of a month will reduce the

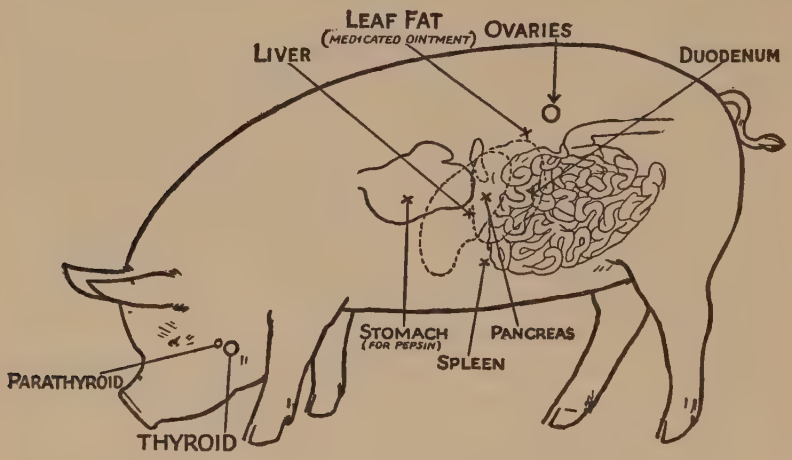


FIG. 35.—Sources of medicinal products from hogs

thymus to one-third of its normal size. It can be looked on as a storage and reserve organ, and, where necessary, children who are given doses of thymus under medical care grow rapidly.

THE PANCREAS.—The pancreas, or sweetbreads, weighing about three ounces, are situated within the abdomen. The internal secretion of this gland regulates the process of carbohydrate metabolism. In this function of regulating the supply of sugar for the main organs of the body, the pancreas is of great significance for body growth and metabolism. Adequate secretion by the pancreas aids in resistance to infections, mental and physical capacity to meet emergencies, and the development of energy. Without a sufficient amount of sugar for the body cells there is possible no

sustained nervous or muscular effort. The pancreas is one of the few glands which have both internal and external secretions. The external secretion, which is evolved by the larger part of the gland, is poured into the small intestine to effect the digestion of starch, fat, and protein. Among the glandular groups of cells in the pancreas are scattered the well-known islands of Langerhans (small collections of cells), of which there are about one million in each pancreatic gland. It is from these islands of Langerhans that Banting and Best isolated insulin, which now has such an important therapeutic value in combating diabetes. The pancreas and the adrenals between them control the sugar mobilization from the liver, where it is stored as glycogen, or animal starch. In this control the pancreas acts as the brake, and the adrenals as the accelerator. These two glands are directly opposed, one on each pan of the scale, in maintaining sugar equilibrium in the body.

THE OVARIES.—As the functions of the ovaries are so fundamental in all physical life, and present the most profound gynecological and obstetrical problems, it is essential, for a clear understanding of the treatment of ovarian disorders, that a short description of them be given here.

The ovaries or testes, in human beings as in higher animals, have a dual function: first, the formation of the reproductive germinal cells (ova and spermatozoa) of their external secretion; and second, the elaboration of hormones, which determine the differentiation of sexes—in a word, control of the so-called "secondary sexual characteristics."

The normal menstrual cycle is largely dependent on ovarian function. The ovary cannot be considered alone, however, for evidences of interrelation of the ductless glands are ever present. The proper development of the ovary seems to depend, to some extent at least, on the functional activity of the pituitary, especially the anterior lobe. There is also a close relation between the thyroid and the ovary, but regarding the exact relation there is no absolute agreement. Again, there is a relation between the ovary and the thymus. This latter organ undergoes involution when puberty occurs, and may furnish some internal secretion to the body

economy before the reproductive glands are functionally able to do so. Embryologically, the ovary and the adrenal cortex are very closely related, for after the menopause the cortex becomes excessively large.

In short, the sex life of the mammalian female is developed and maintained by the ovaries through continuous hormone mechanisms. Hormones, acting more or less continuously, develop and maintain the secondary sex organs and increase basal metabolism; temporary hormones from ripe follicles and corpus luteum initiate the oestral cycle, the early interaction between the fertilized ovum and the uterine membranes, abnormal enlargement of mammary glands, and the suppression of follicular growth.

Anatomically, the ovary consists of an outer cover of a single layer of cubelike cells, embryologically continuous with the mucous membrane of the fallopian tube and uterus. Directly beneath this is a layer of fibrous tissue, and beneath this again is the parenchyma, which comprises most of the bulk of the ovary. This parenchyma is made up of fibrous tissue, characteristic of the ovary and follicles. In the young ovary the follicles are found in great abundance. In later life the number is gradually decreased, until after the menopause there are none. These follicles are constantly changing. With each menstrual cycle a few of them develop toward maturity, but in human beings normally only one reaches it. This one ruptures and discharges an ovum.

From this follicle a corpus luteum (yellow body) develops and then regresses, until it finally becomes a scar with fibrous tissue. This corpus luteum appears as a reddish-yellow mass which fills a ruptured follicle in the ovary. If the discharge of the egg is followed by pregnancy, a much larger and more permanent corpus luteum is formed, which is sometimes called a true corpus luteum, in distinction from the false or small one formed when pregnancy does not follow. The corpus luteum, in its function as an endocrine gland, has a definite inhibitory effect on ovulation and menstruation, or oestrus. The suppression of these phenomena during pregnancy is an example of this effect. The removal of the corpus luteum abolishes this inhibitory effect and accelerates the appear-

ance of the next period. If it occurs during pregnancy, abortion or premature birth may result.

This development and regression of the corpus luteum is repeated with each menstrual cycle. Enlargement of the uterus begins about the time the follicle ruptures. The growth of the uterus continues until there is a sudden change in the corpus, following which menstrual flow occurs and the uterus diminishes in size. On account of this synchronous change in the follicle and in the uterus, it seems logical to conclude that there is a relation of cause and effect. This is borne out by experiment with the follicular hormone.

It is not as yet quite clear just which of these structures is the source of the internal secretion. Both the mature follicle and the corpus luteum of the human female furnish hormones which can substitute for the internal secretion of the ovary in animals in which the ovaries have been removed. This has been called the ovarian follicular hormone. The ovarian secretions may be obtained from the follicles, corpus luteum, and placenta. They are non-specific in action, and can completely substitute for the endocrine ovarian functions in spayed animals.

Ovaries and corpus luteum.—It will be obvious from the foregoing description that the most significant pharmaceutical preparations come from the ovaries of animals and are of great therapeutic value in various disorders in women. This includes corpus luteum and ovarian extracts, both of which are prepared in the form of powder, tablets, or liquid. As far back as 1889 experiments were made with the secretions from the ovaries of various animals, with the view of furnishing a fluid which would maintain the proper functioning of such organs as the uterus, and have beneficial effects upon the metabolism and the nervous system generally. The corpus luteum, for example, is widely recognized as a therapeutic agent, especially for the relief of symptoms following the actual or artificial menopause. For manufacturing the extracts, the ovary containing the corpus luteum is removed while still retaining the animal heat, and the corpus luteum is carefully dissected out. After chilling, it is freed from connective and other

extraneous tissue, and finally minced and dried in vacuo at low temperature. The reason for this precaution is to prevent the coagulation of soluble proteins, and to minimize the oxidation of phosphatids.

Duodenum.—From the mucous membrane of the upper part of the duodenum is produced the hormone known as secretin. It is the function of this hormone, which is released by the action of acid on the tissue, to stimulate the pancreas to pour into the intestine a copious supply of its special digestive ferments.

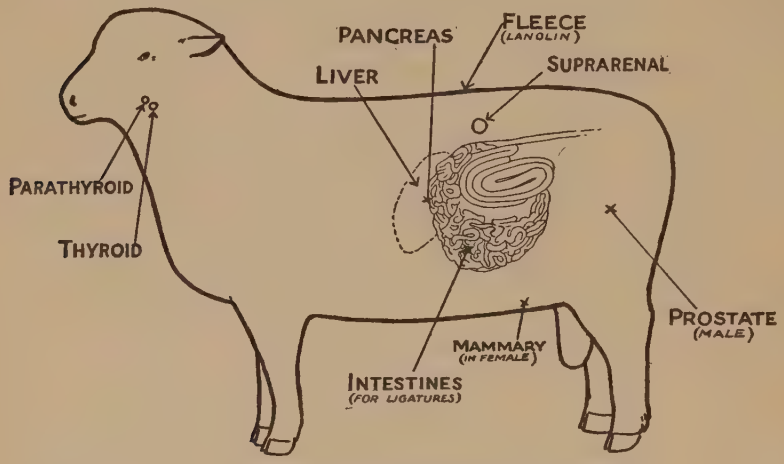


Fig. 36.—Sources of medicinal products from sheep

The liver.—The liver is not always included among the organs of internal secretion. But it is deservedly so classed, if for no other reason than that the carbohydrates are stored there as glycogen, and held in readiness to be converted by a ferment back again to blood sugar, ready for the circulation. The external secretion of this all-important and largest glandular structure is that complex digestive fluid, the bile.

Spleen, prostate, placenta, mammary glands.—A number of other structures, the spleen, the prostate gland, the placenta, and the mammary glands, are also among those which are hormone producing. The list of substances properly classed as hormones will be greatly extended in the future.

PEPSIN OVENS IN PHARMACEUTICAL FACTORY

TRIMMING GLANDS IN PHARMACEUTICAL FACTORY

Problems of Standardization

For satisfactory use of endocrine and other physiological products it is absolutely necessary to secure a uniform chemical composition and therapeutic reaction. Such standardization can usually be achieved only in mass production, where the volume of product warrants the proper biological and chemical controls.

A general rule in standardizing pharmaceutical products is that only products from which the active principle has been isolated sufficiently to know its true physiological character can be prepared. For example, the pituitary contracts all the unstriped muscles, e.g., the intestines, uterus, heart, bladder, etc., and pituitary substances manufactured in a pharmaceutical laboratory must be accurately standardized with reference to effects on these muscles in order to be used with the proper results. This standardization of pituitary substance is carried out by means of tests on an isolated strip of the uterus of a virgin guinea pig. The same reaction must be obtained in each case of testing before the product is put on the market. Another case of standardization is that of suprarenals, or adrenals, which have the effect of increasing blood pressure. Before being put into distributive channels, all suprarenal products are carefully tested on dogs. If, for instance, the blood pressure is raised from 120 to 140, there is an indication of a definite number of units of strength in the product. Each separate run of product must conform to this test. A further instance of standardization is that of kephalin, which is the true hemostatic principle of brain substance, whose clotting properties are determined by absolutely fresh blood. A second class of products presenting a problem in standardization includes those in which it has not been possible, as yet, to isolate the active principle. All that the chemist, who is in charge of standardization, has to guide him is the clinical test and doctors' observation of results, which are reported to him.

Manufacture of pharmaceutical products of animal origin is a highly technical process. Certain methods are, in general, typical of the whole. Speed is absolutely essential in the processing of glandular pharmaceuticals, in order to guard against deterioration

or decomposition, which would destroy the active principle in many glands. Therefore, immediately after the glands are taken from the animal, whether steer, hog, or sheep, they are put through a chilling process. The problem here is to avoid freezing, or the bringing of the glands in contact with water, for this would render them of little value. In the cooler, the glands are spread out in a single layer to insure prompt and thorough chilling. From the chilling room, the glands go to a trimming department, where they can be handled easily since the chilling process makes them firm and enables the fat to be removed without injury to the glands. The glands are then minced and desiccated in shelf vacuum dryers within a narrow range of temperature, so as to preserve the active principle of the gland. In this operation it is possible quickly to evaporate the water from the gland at a temperature of 85°–100° F.

In other cases, the material is powdered or milled as the case may demand. This desiccation takes place below blood heat in a vacuum. The reason for this is to prevent coagulation of any soluble protein in the gland.

Following desiccation, many pharmaceuticals are put through a defatting process. Glands are defatted in a solvent of carbon tetrachloride, which is non-inflammable and non-corrosive. On being defatted, the glands are ground, either in a ball mill, in which pebbles grind the glands into powder, or in a mill similar to a flour mill, which cuts the glands into pieces that are then sifted. When powdered, gland products are tested chemically or standardized physiologically, whichever the case may demand, and are then ready to be bottled or packaged, and dispensed as powders by druggists or physicians, or put in capsules, tablets, or liquid form. Products which are to be put out in liquid form are filtered by sanitary machinery. At this stage, the standardization tests are applied to those products which are capable of accurate standardization in the laboratory. While awaiting distribution, pharmaceuticals are stored in dry, cold, well-ventilated surroundings. Certain products, prior to storage, require filling into packages, tablets, or capsules, for which special machinery is provided.

The medical uses of preparations from some of the more important glands are the following:

Pituitary: Surgery, prevents shock; relieves gas pains. Obstetrics, contracts uterus, expels foetus.

Pineal: Mental backwardness.

Thymus: Rickets.

Pepsin: Dyspepsia and digestive disorders.

Rennin: Milk curdling for cheese making.

Thyroid (used in desiccated form and also in extract form: thyroxin): Deficiency of the thyroid gland, simple goiter.

Spleen: Supplies iron to system.

Orchic: Sexual neurasthenia.

Suprarenal: Yields epinephrin, largely used in surgery.

Suprarenalin: Powerful heart stimulant; increases blood pressure. Styptic, stops blood flow. Snake bites.

Ovaries: Yields ovary extract and corpus luteum (part of ovaries). Menstrual troubles; surgical and natural menopause.

Mammary: Menstrual disorders.

Pancreas: Yields insulin for diabetes treatment. Digestive troubles; predigesting foods, like milk, starch and fat.

Parotid: Replaces saliva in subject deficient.

Parathyroid: Tetanus (caused by deficient parathyroid); paralysis agitans.

Kephalin: Styptic, used in light surgery.

Lecithin: Tonic.

Thromboplastin: Treatment of hemorrhages; dental surgery.

Red bone marrow: Tonic.

Yields of Gland Products

Table XIX is of interest in indicating the yields of the more important gland products.

The striking feature of the table is that in order to prepare one pound of any product, it is necessary to save the glands from a great number of animals. Therefore, the figures in the last column indicate the number of animals from which one pound of the product is secured. For example, it takes 180 cattle to furnish enough pituitary glands to make one pound of fresh product. Some five pounds of fresh glands make one pound of dry product. Therefore, it takes the glands of 900 cattle to make one pound of the

finished pituitary substances. In separating the corpus luteum from cow ovaries, it is necessary to use 20 lb. of the fresh ovaries, which gives 1,600 ovaries, or 800 cows, to produce one pound of the dried substance. For the medical profession, the adrenal or suprarenal extracts manufactured by meat-packers are made from the small glands just above the kidneys of cattle. To make one pound of epinephrin requires about 25,000 beef suprarenals, and so much work is required in obtaining epinephrin that one pound

TABLE XIX

Gland	No. per Lb. (Fresh)	Lbs. Fresh per Lb. Dry	No. per Lb. Finished Product
Pituitary (entire gland)	180	5	900
Pituitary (posterior lobe)	2,000	6	12,000
Ovary (cow)	80	6	480
Ovary (hog)	144	6	864
Ovary (sheep)	600	6	3,600
Ovary (cow)	80	20 (corpus luteum)	1,600
Parathyroid	450	10	4,500
Suprarenal (cattle)	40	630 (epinephrin)	25,200

sells for $5,000. From these instances, some idea is given of the large quantities of glands involved and the difficulties in preparing the final products.

Glands Used in Ancient Times

While the scientific manufacture by meat-packers of medicinal preparations of animal origin dates back only one generation, the use of certain extracts from animal organs for remedying human organic disorders is very ancient. In Greek times Hippocrates, Celsus, and Diosorides recommended the use of various animal organs for the relief of these symptoms in man, which were considered to be due to the defective action of the same organ. Hence, the use of the pigeon's or wolf's liver in cases of hepatic disease, the brains of the hare for tremors, the lung of the fox for dysponea, and the use of rennet for disorders of the stomach and intestines. Pliny recommended the use of the testicles of the donkey and of the stag as aphrodisiacs.

General Chemical and Therapeutic Principles of the Ductless Glands

Preparations made from the thyroid gland affect the pulse rate, blood pressure, and nitrogen metabolism, and should never be used except under a competent physician's direction. Thyroxin, the active principle of the thyroid gland, contains 63 per cent of iodine. It was isolated by Kendall, of the Mayo Research Laboratories, in Rochester, Minnesota. Recently the chemical composition of the active principle of the thyroid gland has finally been completely established by Dr. C. R. Harrington and Professor George Barger of University College, London. These workers, who have received widespread recognition for their successful attempt to manufacture the hormone in the laboratory about a year ago, have definitely ascertained the position of the iodine atoms in the complex thyroxin molecule.

The medical use of posterior pituitary extracts is usually confined to water extracts of the posterior lobe, of which the official solution of pituitary is an example. Such preparations are always put out in hermetically sealed containers. The method of treatment is by hypodermic injection, although sometimes an intranasal spray is used, for instance, in diabetes insipidus. A very important use of pituitary extract is in obstetrics, to promote contraction of the uterus. For habitual constipation the posterior lobe and whole gland preparations are beneficial.

The hormone of the anterior lobe has not yet been isolated as a chemical individual. Regarding the isolation of the specific principle of the posterior lobe, there has been more progress made. Abel holds that there is only a single important specific principle; others believe there are two or more. A tartrate of this principle, isolated by Abel and his associates, exhibited all the activities of a water extract. This tartrate is an extraordinarily powerful stimulant for all smooth muscles. The best and final tartrates are 1,000 to 1,200 times more powerful in their action than the acid phosphate of histamine, which up to the present was one of the most powerful uterus-contracting agents known to medical science.

No other principle of the body has of recent years received such exhaustive study as epinephrin along chemical, physiological, and pharmacological lines. It passes in medical literature under various names, as epinephrin, suprarenalin, adrenalin, suprarenin, adrenin, etc. The official designation is epinephrin, given by Professor Abel.

One of the great fields of effort for the constructive chemist is the isolation study, and, if need be, the preparation, of pure principles of our organs of secretion and of other principles of vital importance to healthy life. First, the presence of a vasoconstrictor principle was established in the suprarenal or adrenal glands, the small glands situated just above the kidneys. Then, by brilliant research, Professor John J. Abel, of the Johns Hopkins University, one of the pioneers and leading authorities on endocrinology, succeeded in isolating this principle, epinephrin (adrenalin), in the form of a derivative, and prepared a number of salts of the latter. Some time afterward the pure basic principle itself was precipitated by means of ammonia, a precipitating agent which Professor Abel had already used in this work. Its chemical structure was later determined, with the result that epinephrin can now be prepared artificially. The world is richer for the wide sources of manufacture of this valuable drug.

Some of the great advantages of the isolation of this pure principle (epinephrin) are these: it is injected with local anesthetics (procaine, etc), causing constriction of the blood vessels and preventing a rapid local loss of the anesthetic, thus reducing the amount needed very materially and, correspondingly, the danger of toxic effects. Injected hypodermically, epinephrin allays within a few minutes the spasms of acute bronchial asthma, an untold blessing which those can only realize who have witnessed the acute suffering of victims of it. Epinephrin may also be used for the quick arrest of hemorrhage of a capillary character.

It has been established with certainty that the cortex of the suprarenal is essential to the maintenance of life, as death always occurs in animals of widely different species within about thirty

hours after its removal. The results following ablation of the cortex alone, therefore, completely justify the original contention of Addison that the suprarenal glands are of the greatest importance, and that life cannot be continued after their removal or destruction by disease.

Diabetes is a disease for which only recently a remedy or cure has been found in a remarkable extract from one of the glands in animals. This remedy is the famous insulin, which was discovered a few years ago by Canadian scientists. The great benefit of this discovery can be understood when it is realized that there are some one million cases of diabetes in the United States, more largely among people in middle and late life, and among men rather than women. Essentially, diabetes is a disease produced by deficiency in the secretion of the islands of Langerhans in the pancreas, which regulates the sugar content of the body and carbohydrate metabolism. Such deficiency throws the body-functioning out of equilibrium, and it is to restore this equilibrium that insulin is administered.

The story of the discovery of insulin is most interesting. Many attempts had been made to isolate a substance from the pancreas which would supply the deficiency in diabetes, just as thyroid extract does in goiter and cretinism. Between 1900 and 1920 many investigators just missed success in separating the internal secretion, insulin, from the external secretion. Finally the discoverers of insulin, Dr. Banting and his associates, proceeded on the hypothesis that the external digestive juices of the pancreas destroyed the internal secretion of the islands of Langerhans when they were extracted together, and that if the latter could be extracted separately, it might prove to be the substance lacking in diabetes. The substance was finally isolated on July 30, 1921, and had the desired beneficial effect on blood sugar.

Shortly after this, a practical commercial method of extracting insulin from fresh beef pancreas by means of alcohol was developed. The present process of manufacture consists in extracting insulin from fresh cattle, sheep, or hog pancreases,

and purifying this insulin to make it safe for injection by isoelectric precipitation methods. The result is an insulin powder which is dissolved in a slightly acid solution and is then ready for injection. All insulin extract is standardized and made of uniform strength by testing its effect on the blood sugar of rabbits before it is put into commercial distribution. Because the digestive juices of the stomach and intestines destroy its potency, insulin cannot be given through the mouth, but must be hypodermically administered. For some six or eight hours after injection, insulin supplies the deficiency in diabetes and makes the diabetic metabolism normal. However, when the effect wears off, the diabetes patient relapses to the former condition.

While the insulin separated by the Toronto scientists was sufficiently purified for all therapeutic uses, it was amorphous in character and contained considerable protein impurities. The honor of isolating the pure crystalline insulin belongs to Professor John J. Abel and his co-workers at the Johns Hopkins Medical School in Baltimore.

Various other extracts are prepared from the pancreas which are of use in treating diseases other than diabetes; for example, pancreas substance in powder form, which represents, in fact, the entire pancreatic gland, is used for the relief of carbohydrate indigestion. Again, pancreatin, a light-colored odorless extract of the pancreas, is a remedy in cases of intestinal indigestion and other internal disturbances. It contains elements which convert starch into sugar, emulsify fats, and transfer complex proteids into peptones and amino acids.

The isolation of chemically pure substances that represent the active principles of other ductless glands, such as epinephrin, thyroxin, pituitary extract, and insulin, stimulated the preparation of various extracts of the ovary for the treatment of ovarian disorders. The first serious attempts at ovarian therapy were in 1896 in Berlin, by Landau, the preparation used being the fresh ovarian substance obtained from the cow or sow. Fraenkel, the foster father of the corpus luteum theory of menstruation, is responsible also for the use of the corpus luteum extract, which was

popularized after 1904. A third preparation was suggested by Graves in 1919. It is obtained from that portion of the ovary remaining after removal of the corpus luteum. The commercial preparations available are extracts of the whole ovary, corpus luteum, and the ovarian residue. All these are procurable in the form of tablets, capsules, powder, or watery solutions.

Digestive Ferments

Somewhat distinct from the pharmaceutical products already discussed are the digestive ferments, or enzymes, which are prepared from three sources, viz., the stomach lining from hogs, which produces pepsin, the lining of the fourth stomach of calves, which produces rennin, and the pancreas of hogs, which produces diastase, lipase, and trypsin.

Of these the most widely known is pepsin, which was one of the earliest pharmaceutical products manufactured in the packing industry. Pepsin is pale yellow, and when manufactured as a pharmaceutical, appears as lustrous scales, granules, or springy masses, or as a fine white or cream-colored amorphous powder, nearly odorless, with a slightly acid or saline taste. In the making of pepsin on a commercial scale, the glandular part of the hog stomach is cut up and separated on the killing floor from the muscular tissue, washed, chilled, and kept in this state until used. When this raw material for pepsin making is processed, it is mixed with water and hydrochloric acid, and digested artificially at a temperature a little above normal body heat. The product is then allowed to stand, and most of the mucin settles to the bottom as a precipitate. On completion of this step, the golden-yellow liquid is filtered and purified either by dialysis or fractional precipitation. Finally, it is dried in vacuum at a low temperature, not above 120° F., and appears in a spongy granular form, ready for sale. For certain types of trade, this product may be powdered and packaged in various sizes.

Recently a method for isoelectric precipitation of pepsin has been developed by Fenger and Andrew, of the Research Laboratory in Organo-therapeutics, Armour & Company, Chicago. For

future rational development of medicinal products, it is necessary that in each case the active principle be isolated and studied very carefully. By purification and isoelectric precipitation a fraction was isolated which showed a proteolytic power of 1:70,000. This means that one part of the enzyme is capable of liquefying 70,000 times its own weight of hard-boiled egg white, under the conditions specified by the United States Pharmacopoeia. The purified enzyme is a nearly ash-free protein, quite insoluble in distilled water, but clearly and completely soluble in acidulated water.

The chief and very wide use of pepsin is in cases of failure of the digestive functions of the stomach. Pepsin is a substitute for the natural gastric secretion, both for old and young. For example, it is beneficial in the peptonizing of milk for infants; and for adults, for a prolonged illness such as typhoid fever, small amounts of pepsin, administered with a dilute hydrochloric acid, aid in the proper digestion of food. An interesting fact is that pepsin ferment is inactive when given as a medicine, unless combined with hydrochloric acid. Another use for pepsin is that of removing tissue from unhealthy wounds. Essence of pepsin is usually produced from the fresh glandular layer of hog stomachs, and contains the active gastric enzymes in palatable, stable, liquid form, which is used principally to relieve gastric discomfort resulting from insufficient peptic secretion.

The second digestive ferment, which acts in acid media, is rennin, which is the purified and activated enzyme from the fourth stomach of suckling calves. It is largely used in cheese making and in the manufacture of ice cream. The commercial product will curdle 30,000 times its own weight of pasteurized milk in twelve to fifteen minutes. By isoelectric precipitation Fenger has separated a highly purified rennin which curdled more than 2,000,000 parts of fresh milk in ten minutes. The pancreas from herbivorous animals, such as cattle and sheep, is not suitable for the production of pancreatin. It is employed almost exclusively for its insulin contents, a fact which indicates its possibilities.

The third group of digestive ferments is produced from the hog

pancreas through three enzymes—diastase, lipase, and trypsin—which are necessary for the proper digestion of starches, fat, and protein, respectively. The official preparation contains these three enzymes in activated form, and is called pancreatin. Diastase is used for the predigestion of starches, and trypsin for the predigestion of foods in general. A technical use for trypsin is in the bating process of leather tanning.

Peptones

The peptones represent a distinct group of pharmaceutical products, although they are not made from the glands of animals. Of these, peptone solution is prepared from the straight lean muscle tissue of beef, and is used hypodermically in the treatment of urticaria, migraine, bronchial asthma, and other allergies of obscure digestive origin. Another product, peptonum siccum, prepared by one packer, is a peptone used in bacteriological research, e.g., in making culture media for the examination of water, milk, sewage, etc. Other forms of peptone have a use as predigested foods. For example, beef peptone is made from fresh lean beef by a special peptonizing process which renders all the food elements in the beef soluble. It is then ready for use by food manufacturers in preparing liquid forms of food of especial service to invalids. Another product called "peptonal" is predigested lean beef and malt extract, which is of benefit in cases of malnutrition and where the stomach cannot retain solid food and ordinary ingredients of diet.

Thromboplastin

A pharmaceutical product which has proved of great use as a blood coagulant is thromboplastin, a specific hemostatic agent made exclusively from the brain tissue of cattle. However, due to the fact that the stunning of cattle in ordinary slaughter operations injures the brain tissues, rendering them unfit for the manufacture of thromboplastin, the material for its production comes from koshered cattle which are slaughtered without stunning. After the animals are bled, the brain tissues are removed, carefully trimmed, washed and cleaned, and from this material a solu-

tion is made containing the hemostatic principles. This thromboplastin solution is useful in checking capillary oozings. Its method of treatment is by means of a spray upon the bleeding surface, or directly by means of gauze or cotton.

A practical method for making thromboplastin solution was first outlined by Hess in the research laboratories of the New York City Department of Health. Professor Howell, of the Johns Hopkins Medical School, has shown that thromboplastin from every source contains the phosphated kephalin, and that the facilitating influence of thromboplastin on coagulation is due to the action of the kephalin.

Liver Extracts

Pernicious anemia, a disease that almost always is fatal, may come within the practical control of science. And ordinary beef liver is the source of the material being used in the treatment. Scientists have established as a fact that a diet rich in liver increases the number of red blood corpuscles and their hemoglobin content in patients with this disease, and they are now endeavoring to isolate the active principle or principles in liver responsible for this improvement. A considerable number of patients have been successfully treated for from one to three years with a diet containing approximately 200 grams of liver a day. Even if the individual with pernicious anemia knows that he is the gainer thereby, a daily diet of liver in the quantities necessary to replenish the blood with red corpuscles is difficult to take for a long time. Consequently, a small dose of liver extract daily that does as much good as 200 grams or more of the whole liver represents a big advance in the treatment of this disease. The causes of this fairly common malady are obscure, though it is believed by some that a predisposition toward it is inheritable. This disease should not be confused with anemia due to common causes.

Minot and other members of the Department of Physiological Chemistry in the Harvard Medical School have isolated a fraction of liver that promptly produces young red blood cells and permits the total number of red blood cells to increase. Others are deter-

mining the effectiveness and the clinical uses of the successively purified extracts that are being prepared. These scientists report that the most concentrated preparation that has thus far been administered produced about four times its weight of erythrocytes, or red blood cells, within a fortnight. An effective daily dose amounts to about one-third of an ounce, or 10 grams. Nine patients with pernicious anemia have been fed the extract with entire success recently.

Chemists are still uncertain as to the exact amount of the effective substance in the liver extract, since, despite the fact that the purification has proceeded far, a large part of the material in the present mixture may eventually prove to be inert. After further purification, it may be possible to isolate the chemical substance or substances that are specifically involved, and thereby learn more of the reactions and of the physiological mechanisms that are disturbed in this disease. The development of the use of liver extract in the treatment of pernicious anemia may be as important in its way as the outstanding achievement in the treatment of diabetes by the use of insulin.

Another product of medicinal value secreted by the liver is bile. One of the functions of the bile is to emulsify the fats, thereby aiding the fat-splitting enzyme, lipase. Purified bile in inspissated and desiccated forms, as well as the isolated bile salts—sodium taurocholate, and sodium pzcocholate—are employed extensively in the manufacture of various medicinal preparations.

A pharmaceutical product which is of considerable importance but cannot be considered as a gland product, is extract of red bone marrow. According to Leake, of the Department of Pharmacology, University of Wisconsin, red bone marrow stimulates the production of red blood cells. The erythropoietic agents are stable under heat at 100° C., are soluble in water, do not deteriorate on standing in sterile solution, are effective by mouth, and have no untoward accessory pharmaceutical actions. Red bone marrow is often prescribed in conjunction with spleen preparations.

Surgical Catgut Ligatures

Surgical ligatures made from the intestines of sheep are logically considered under the head of pharmaceutical products since they are distributed by the same channels to the medical profession; but they are not produced from animal glands, nor are they made from catgut, as is so often thought by the general public. Surgical ligature material comes only from inspected sheep, and the whole manufacturing process is carried on under careful chemical and bacteriological control and standardized methods. The perfecting of processes for such surgical ligatures has resulted in significant advances in methods of surgery and greater comfort and speed in recovery for thousands of people who have been operated upon for various ills. The sheep intestines to be converted into surgical ligatures are kept at a temperature near freezing, in order to eliminate fermentation and bacterial growth, and after thorough cleansing, the intestines are carefully sterilized. The intestines so treated are then spun, dried, and polished until perfectly smooth. All moisture is removed by careful drying processes, the finished product is placed in tubes covered with strong fluid, and after sealing, these containers receive a final sterilization before the ligatures are put into distribution for the use of surgeons.

Increasing Use of Pharmaceuticals

The pharmaceutical preparations manufactured in the packing industry, as already outlined in a general way, indicate the great range of human diseases which are benefited, if not cured, by the administration of the proper pharmaceutical product under capable medical direction. While the service rendered by these pharmaceuticals has been of inestimable value from a social point of view, the manufacture of pharmaceuticals is a profitable part of the packing industry, although the volume of product is comparatively small. This volume is increasing year by year, however, as the demand from the medical profession is ever greater. For pharmaceuticals are sold, not to the general public, but to the medical

profession and pharmacists only. Incidents have been cited, especially those regarding insulin, which indicate that scientific discoveries are being made continuously which are constantly extending the use of pharmaceutical products. The remarkable progress in the last five years would seem to show that prophecy regarding the ultimate extent of these therapeutic agents falls far short of the actual results. The final analysis of the mysterious and elusive phenomena that are encountered in the field of endocrinology will no doubt continue to fascinate and challenge the intellect of investigators for centuries to come.

CHAPTER VIII

EDIBLE MEAT BY-PRODUCTS[1]

The primary product of meat animals is meat, i.e., dressed beef and pork. But there are many other products from meat animals which are edible and which yield a considerable supply of nourishing food to consumers and a substantial financial return to packers. Edible meat by-products are defined by the United States Department of Agriculture as "any clean, sound, and properly dressed edible parts other than meat which have been derived from one or more carcasses of cattle, of swine, of sheep, or of goats sufficiently mature and in good health at the time of slaughter." On the other hand, in the meat industry there is a special trade use of the term "by-products." What are usually called by-products, strictly speaking, include in the meat trade only inedible products, while meat specialties is the name applied to edible products. In this book, however, the term "meat by-products" means edible products.

The edible meat by-products from hogs include brains, cheek and head meat, cutlets, ears, faces, giblet meat, hearts, kidneys, leaf lard, lips, livers, melts, snouts, stomachs, tongues, sweetbreads, sausage trimmings, chitterlings, and tails.

The edible meat by-products from cattle are brains, cheeks, fries, giblet meat, heads, head meat, kidneys, livers, lips, lungs, melts, ox tails, rennets, sweetbreads, snouts, tongues, and tripe.

The edible meat products from sheep include brains, cheek and head meat, cutlets, ears, faces, giblet meat, heads, hearts, kidneys, leaf lard, lips, livers, melts, snouts, stomachs, and tongues.

[1] The author is greatly indebted to the Committee on Practical Research of the Institute of American Meat Packers for permission to use technical data from the revised edition of *Readings in Packing-House Practice*, Part III, "Manufacturing Operations," prepared by the Committee for the Institute of Meat Packing, 1927.

The first group of edible pork by-products consists of hog heads and edible pork specialties. The preparation of these products is completed as close as possible to the killing floor, to save labor, to decrease expense, to preserve the product, and to secure high yields and quality. From hog heads the tongues are removed, chilled, and sent to the market fresh or cured in sweet pickle. Ears are also chilled, and sold, fresh or pickled, as a delicacy. Snouts, after being removed by a snout puller, are chilled and marketed fresh, disposed of to the sausage department or sausage

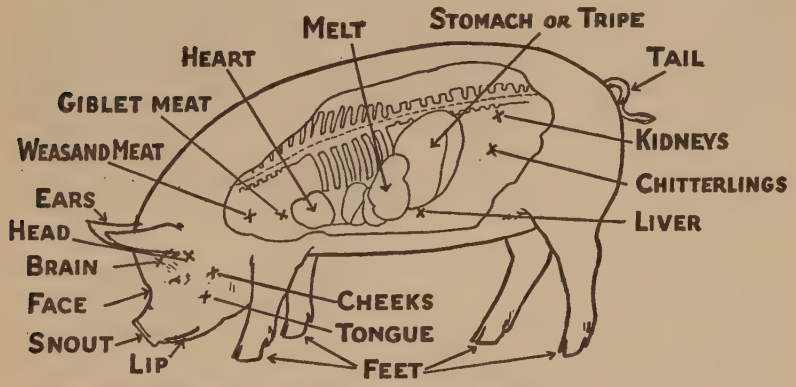


FIG. 37.—Edible pork products (other than fresh and Cured pork cuts)

manufacturers, or cooked and sold as a ready-to-serve meat specialty. Cheek meat is chiseled from the jaws with a small steel instrument, and then is chilled and sold to markets as ready-to-serve meat specialties, or to sausage manufacturers. Likewise, brains are removed, chilled, and sold fresh in boxes or cans.

All pork trimmings can be used for sausage making, and the fat goes into lard. The yield of the various products of the head depend upon the general market conditions, which determine whether ears, snouts, etc., will bring more money as such, or when made into lard. Another factor is the skill in separation of the parts, in order to produce the maximum yield after market conditions have been analyzed. Local market conditions and tastes guide packers in the proportion of the various specialties to be put on the market at any given time.

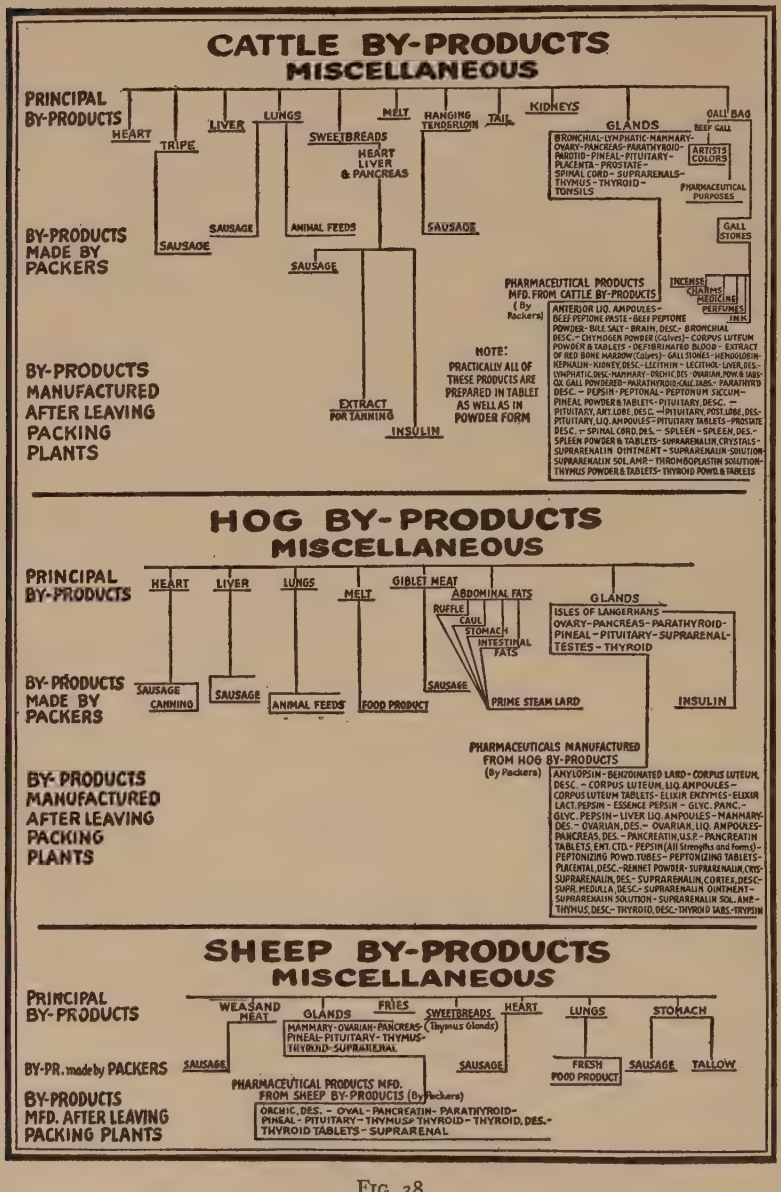

CATTLE BY-PRODUCTS
MISCELLANEOUS
PRINCIPAL BY-PRODUCTS
HEART
TRIPE
LIVER
LUNGS
SWEETBREADS
MELT
HEART LIVER & PANCREAS
RANGING TENDERLOIN
TAIL
KIDNEYS
GLANDS
GALL BAG
BEEF GALL
ARTISTS COLORS
PHARMACEUTICAL PURPOSES
BRONCHIAL-LYMPHATIC-MAMMARY-OVARY-PANCREAS-PARATHYROID-PAROTID-PINEAL-PITUITARY-PLACENTA-PROSTATE-SPINAL CORD-SUPRARENALS-THYMUS-THYROID-TONSILS
BY-PRODUCTS MADE BY PACKERS
SAUSAGE
ANIMAL FEEDS
GALL STONES
INCENSE
CHARMS
MEDICINE
PERFUMES
INK
PHARMACEUTICAL PRODUCTS MFD. FROM CATTLE BY-PRODUCTS (By Packers)
ANTERIOR LIQ. AMPOULES-BEEF PEPTONE PASTE-BEEF PEPTONE POWDER-BILE SALT-BRAIN, DESC.-BRONCHIAL DESC.-CHYMOGEN POWDER (Calves)-CORPUS LUTEUM POWDER & TABLETS-DEFIBRINATED BLOOD-EXTRACT OF RED BONE MARROW (Calves)-GALL STONES-HEMOGLOBIN-KEPHALIN-KIDNEY, DESC.-LECITHIN-LECITHOL-LIVER, DES.-LYMPHATIC, DESC.-MAMMARY-ORCHIC DES.-OVARIAN, POW. & TABS.-OX GALL POWDERED-PARATHYROID-CALC. TABS.-PARATHYRD DESC.-PEPSIN-PEPTONAL-PEPTONUM SICCUM-PINEAL POWDER & TABLETS-PITUITARY, DESC.-PITUITARY, ANT. LOBE, DES. C.-PITUITARY, POST. LOBE, DES.-PITUITARY, LIQ. AMPOULES-PITUITARY TABLETS-PROSTATE DESC.-SPINAL CORD, DES.-SPLEEN-SPLEEN, DES.-SPLEEN POWDER & TABLETS-SUPRARENALIN, CRYSTALS-SUPRARENALIN OINTMENT-SUPRARENALIN SOLUTION-SUPRARENALIN SOL. AMP.-THROMBOPLASTIN SOLUTION-THYMUS POWDER & TABLETS-THYROID POWD. & TABLETS
BY-PRODUCTS MANUFACTURED AFTER LEAVING PACKING PLANTS
EXTRACT FOR TANNING
INSULIN
NOTE: PRACTICALLY ALL OF THESE PRODUCTS ARE PREPARED IN TABLET AS WELL AS IN POWDER FORM
HOG BY-PRODUCTS
MISCELLANEOUS
PRINCIPAL BY-PRODUCTS
HEART
LIVER
LUNGS
MELT
GIBLET MEAT
ABDOMINAL FATS
RUFFLE
CAUL
STOMACH
INTESTINAL FATS
GLANDS
ISLES OF LANGERHANS
OVARY-PANCREAS-PARATHYROID-PINEAL-PITUITARY-SUPRARENAL-TESTES-THYROID
BY-PRODUCTS MADE BY PACKERS
SAUSAGE CANNING
SAUSAGE
ANIMAL FEEDS
FOOD PRODUCT
SAUSAGE
PRIME STEAM LARD
INSULIN
PHARMACEUTICALS MANUFACTURED FROM HOG BY-PRODUCTS (By Packers)
ANYLOPSIN-BENZOINATED LARD-CORPUS LUTEUM, DESC.-CORPUS LUTEUM, LIQ. AMPOULES-CORPUS LUTEUM TABLETS-ELIXIR ENZYMES-ELIXIR LACT. PEPSIN-ESSENCE PEPSIN-GLYC. PANC.-GLYC. PEPSIN-LIVER, LIQ. AMPOULES-MAMMARY-DES.-OVARIAN, DES.-OVARIAN, LIQ. AMPOULES-PANCREAS, DES.-PANCREATIN, U.S.P.-PANCREATIN TABLETS, ENT. CTD.-PEPSIN (All Strengths and forms)-PEPTONIZING POWD. TUBES-PEPTONIZING TABLETS-PLACENTAL, DESC.-RENNET POWDER-SUPRARENALIN, CRYS-SUPRARENALIN, DES.-SUPRARENALIN, CORTEX, DESC-SUPR. MEDULLA, DESC.-SUPRARENALIN OINTMENT-SUPRARENALIN SOLUTION-SUPRARENALIN SOL. AMP.-THYMUS, DESC.-THYROID, DESC.-THYROID TABS.-TRYPSIN
BY-PRODUCTS MANUFACTURED AFTER LEAVING PACKING PLANTS
SHEEP BY-PRODUCTS
MISCELLANEOUS
PRINCIPAL BY-PRODUCTS
WEASAND MEAT
GLANDS
FRIES
SWEETBREADS (Thymus Glands)
HEART
LUNGS
STOMACH
MAMMARY-OVARIAN-PANCREAS-PINEAL-PITUITARY-THYMUS-THYROID-SUPRARENAL
BY-PR. made by PACKERS
SAUSAGE
SAUSAGE
FRESH FOOD PRODUCT
SAUSAGE
TALLOW
PHARMACEUTICAL PRODUCTS MFD. FROM SHEEP BY-PRODUCTS (By Packers)
BY-PRODUCTS MFD. AFTER LEAVING PACKING PLANTS
ORCHIC, DES.-OVAL-PANCREATIN-PARATHYROID-PINEAL-PITUITARY-THYMUS-THYROID-THYROID, DES.-THYROID TABLETS-SUPRARENAL

FIG. 38

The viscera of hogs, after careful inspection, are separated into different products. First, the bung guts are graded for use as commercial sausage casings. Next, the viscera products are removed, including the pluck (trachea, esophagus, lungs, liver, and heart) and the stomach. Of these, the trachea goes into lard; the esophagus is used in the manufacture of sausage; the lungs are inedible and go into tankage; the livers are edible, and are either chilled or made into liver sausage; the heart is an edible meat specialty; the stomach, after trimming and cleansing, is rendered into killing lard, cooked as tripe for sausage manufacture, or used as sausage containers; and the pepsin surface (pyloric end) of the stomach is utilized in the manufacture of pepsin. The rest of the viscera consists of the ruffle fat, used in lard, and intestines for casings.

The pancreas, or hog sweetbreads, are frozen thoroughly at subzero temperatures and kept in storage freezers until shipment for the extraction from the pancreatin gland of the noted diabetes cure, insulin. Chitterlings are cleansed and kept in a quick freezer until shipment. Pigs' feet are trimmed of hair, scurf, and toe nails, chilled, and sold fresh, pickled and sold as a delicacy, or tanked for use in lard.

Sausage Manufacturing

At least from the time of the Greeks, sausage has been a staple human food. Through the many changes of time and nationalities there have been developed the hundreds of varieties of sausage of today. Every country has its peculiar styles and grades of sausage, beef and pork, fresh and dried, smoked and unsmoked, cooked and raw, seasoned and unseasoned, *ad infinitum*. Each of these styles of sausage is quite distinct and necessary for the nationality for whom it is designed, and needs myriad sizes, shapes, and appearances of casings as identification. Sausage is such an important by-product of the meat-packing industry that its manufacture constitutes a large-scale business in itself, requiring careful supervision, unusual skill, close attention to detail, exact technical knowledge, and expert handling.

The total production of sausage and sausage casings in the United States is given by the United States census as follows:

PRODUCTION OF SAUSAGE AND SAUSAGE CASINGS, YEAR 1923
(VALUE REPORTED BY ESTABLISHMENTS)

In slaughtering and meat-packing industry...	*$146,801,410
Engaged principally in manufacturing sausage	65,133,075
In other industries.....	107,209
Total value.....	$212,041,694

* Not including canned sausage.

Separating the figures into the two general classes of sausage and sausage casings used in the United States census reports, we have for the years 1923, 1921, and 1914 figures as shown in Table XX.

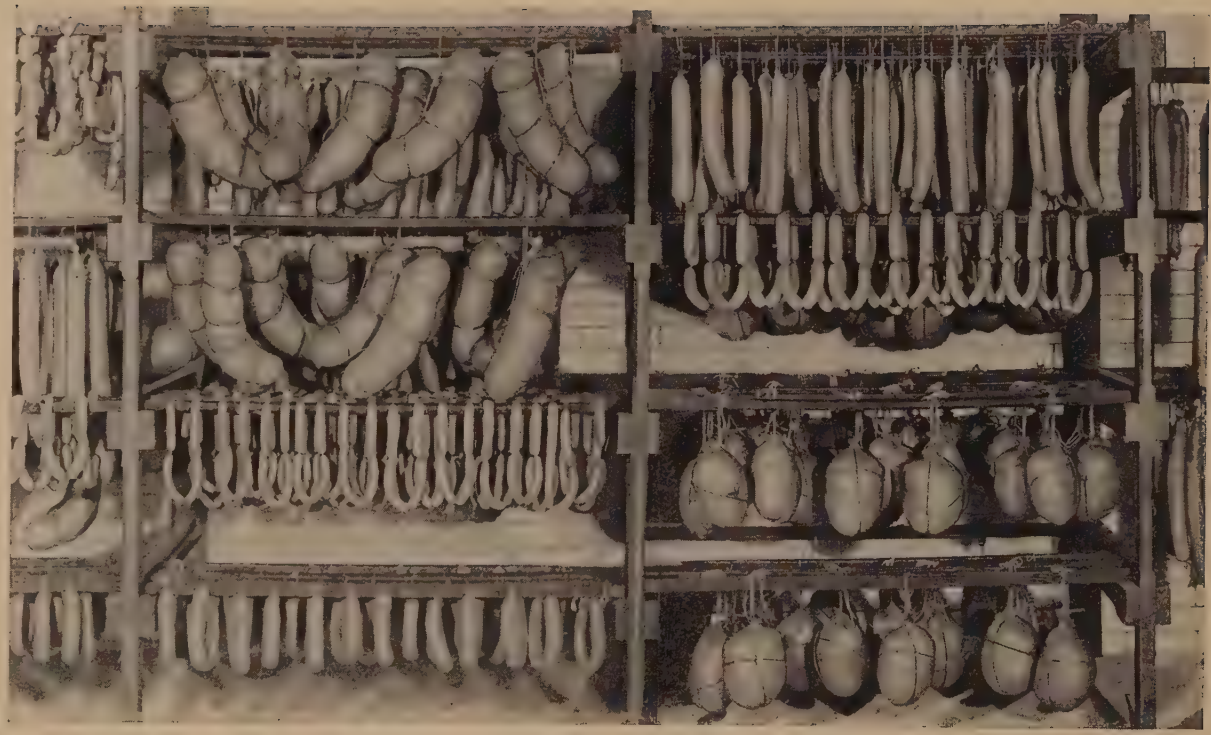
TABLE XX

PRODUCTION OF SAUSAGE

	1923	1921	1914
Canned meat and canned sausage:			
Pounds.....	95,133,635	74,586,052	*234,803,335
Value.....	$ 19,703,137	$ 16,335,568	$ 36,263,293
Sausage (not canned, puddings, head cheese, scrapple, etc.):			
Pounds.....	803,722,352	603,996,272	477,486,857
Value.....	$133,054,311	$106,116,267	$ 62,838,314
Sausage casings:			
Pounds.....	96,274,163	86,079,314	69,453,298
Value.....	$ 13,747,099	$ 12,030,471	$ 9,077,593

* War demand.

In the production of sausage by federally inspected plants, the leading states follow in order of rank: Illinois, Pennsylvania, New York, Ohio, Kansas, Massachusetts, Minnesota, Nebraska, Indiana, Missouri, Wisconsin, and Texas. However, national statistics of sausage production are not comprehensive because the amount of sausage manufactured under government inspection is probably only 50 per cent of the total. It is a well-known fact, for example, that stores and butcher shops throughout the country grind and make their own sausage in large quantities each year with the advent of cooler weather.



VARIETIES OF SAUSAGE IN WHOLESALE MARKET

Today there are some sixty-five grades of dry sausage, and about the same number, if not more, of fresh sausage. For the processing of both fresh and dry sausage, 20–35 lb. of sausage materials per hog can be produced. Sausage materials also include beef, especially chucks, shanks, and trimmings. The situation would be ideal for the packer if sausage departments could use all of the pork and beef, except wholesale cuts, produced by the packing-houses. At present the sausage business takes most of the pork, but does not demand all of the beef material. This condition creates effective competition in determining prices for sausage materials, since it is necessary for packers with surplus beef to vend it to other sausage manufacturers, thereby creating market quotations and providing a basis in packing-house accounting for valuing trimmings and other sausage materials.

Classification of Sausage

Generally speaking, there are three main classes of sausage: (1) Fresh sausage made from fresh meats and sold fresh, for which reason fresh sausage does not keep long at normal temperatures, and must be thoroughly cooked before being eaten. (2) Smoked or cooked sausage, which, possessing good keeping qualities, does not need to be cooked before serving. (3) Dry, or summer, sausage, which requires no cooking before serving, as it is so cured and dried that it has good keeping qualities even at rather high temperatures.

Made from fresh materials, especially fresh pork, "breakfast sausage," or fresh sausage, is manufactured by grinding up meat in a hasher, running it into a mixer where it is thoroughly mixed with definite quantities of salt, pepper, and sage, or other spices according to formula, and packing the product in bulk, or transferring it to a sausage stuffer, where the meat is stuffed into casings and linked. The linked sausage is then hung upon sausage sticks until dry, when it is packed in 1-, 5-, or 10-pound cartons, or is packed in bulk. Besides pure pork sausage, fresh sausage may be made from beef, mutton, veal, or from meat specialties, with the frequent addition of water and cereal, according to spe-

cific formulas. The term "fresh sausage" is somewhat of a misnomer. When people think of fresh sausage they have in mind pork sausage. The correct term, in keeping with the facts of the trade, is "cooked meats," a term which includes pork sausage and luncheon meats, bologna, frankfurters, meat loaves, etc. A partial classification of the products included under the term "fresh or smoked sausage" includes blood pudding, bologna sausage, chili con carne, frankfurter sausage, Hamburger steak, head cheese, liver sausage, luncheon meat (minced luncheon meat; pressed loaf), pork sausage, Polish sausage, scrapple (Pennsylvania), souse, loin roll, jellied lamb tongue, jellied luncheon tongue, jellied pigs' feet, cooked whole ox tongue, cooked luncheon tongue, corned beef and gelatin, cooked steamed roast beef, meat loaf, and veal loaf.

A great variety of sausage is included under the head of smoked and cooked sausage, e.g., frankfurters, wieners, bologna, ham sausage, blood sausage, liver sausage, and minced sausage, which are stuffed into beef, sheep, or hog casings. To make smoked sausage, the sausage meat is first cured, in order to produce a color and flavor desired for the particular style of sausage to be made and to preserve the meat. This curing process usually takes three to five days, and the product is then stuffed into casings and smoked. This process of smoking, which runs from forty-five minutes to three hours, imparts a desirable appetizing flavor and a permanent, deep-red color which the trade demands. After smoking, the sausage cages are removed from the smokehouse, the sticks upon which the sausage is hung are taken out, and the sausages are immersed in a cooking vat filled with hot water at cooking temperature. A cold-water shower is then given the sausages and they are placed in 5- and 10-pound cartons.

Dry sausage, the other main type of sausage, differs from fresh sausage largely in the fact that it is a highly concentrated manufactured product which is processed by drying, curing, etc., and usually is prepared months before it can be consumed. For this reason, dry sausage does not have as quick a turnover as fresh sausage. Dry sausage includes a great many varieties of

product which can be classified in different ways. For example, the three main classes of dry sausage are called summer sausage, salami, and mortadella. But dry sausage can be divided in other ways, as in the Italian, the German, the Scandinavian, and the French classes. Dry, or summer, sausage is produced in large quantities, including the following varieties: German and Italian, salami, cervelat, Genoa, peperoni, frizzes, Holstein, farmer, and many others. Of these, salamis are coarsely chopped, and cervelats are finely chopped. Sometimes the same product stuffed into different kinds of casings bears different names. Broadly speaking, dry sausage can be divided into two general classes: smoked dry sausage, and unsmoked dry sausage. In a general way the unsmoked varieties are preferred by the Latin, and the smoked by the northern- and central-European races. So many varieties are becoming popular with Americans that there might well now be added the American class, somewhat lighter in seasoning and milder in flavor. Classification of dry sausage according to treatment is given here as follows:

Smoked.—Summer sausage, B.C. salami, Göteborg, Mettwurst, Holstein, farmer, Landjaeger, Nola, Austrian pork, Lebanon, chorizos.

Unsmoked.—Milan salami, Coppa, Capicolli, Arles, Menage, sopressata, frizzes, peperoni, Genoa, Alessandria, Alpino, La Stella, Lombardia, Italian pork, salamini corti, Lyons, Sicilian, prosciutti, bobbio.

Cooked.—Mortadella, salami.

Some of the advantages of dry sausage are as follows: It is a highly concentrated meat product; it is a staple product, not depending upon seasons or conditions; it is an economical form of food; it will keep almost indefinitely; there is no waste; and it requires no preparation.

Dry sausage is a blending of selected beef and pork, chopped, mixed, and seasoned to suit the trade for which it is intended. The sausage is cured and dried thoroughly, and some grades are smoked after being stuffed into casings selected with some particular demand in mind. The amount of pork in dry sausage is usually

greater than that of beef, because pork, when cured, has a tendency to cut much brighter and is more tender, while beef cuts with a dark color after curing. Dry sausage is not a raw product, but a prepared meat, ready to eat. The process of curing and drying and also smoking makes this product very edible and appetizing. The meats from which dry sausage is prepared are of the same choice quality as the prime cuts from which they have been taken. Therefore dry sausage is in all respects a quality product and its manufacture involves great skill and study.

Making of Sausage

A brief survey of the manufacturing process will make this clear. The pork and beef used in the manufacture of dry sausage are selected with care and judgment, and this selection is standardized. Pork and beef may vary in price and quality, but the formula on which every grade of dry sausage is based must always measure up to very definite and rigid standards, regardless of cost or scarcity of material, because it is absolutely essential that the product be unvarying in appearance and quality. After the materials have been selected, the meat is chopped on "rockers," a series of parallel knives rocking back and forth on a revolving table. At the same time the necessary seasoning is added, each kind of sausage having its own particular flavor. Only a master hand can blend the ingredients to suit individual tastes, which demand in each grade of sausage a delicate but definite flavor. The mixing of the meat, as well as of the condiments, is highly important.

The same care is exercised in the selection of casings as in the selection of meats. The casings are thoroughly cleansed, inspected, and tested, after which they are cured in tierces. Curing is followed by a thorough soaking and washing, and finally, after being reversed so that the smooth part is outermost, the casings are cut into suitable lengths and tied at one end. The selection of the casings to be used is an important matter. As a rule, it is limited to the intestines of hogs and cattle. The parts of the intestines used are classified according to the size and shape given them by nature. The importance of the selection lies in the fact that certain

CHOPPING AND MIXING SAUSAGE MEAT

STUFFING SAUSAGE CONTAINERS

styles of sausage differ from each other only in the kind of casing used, this being determined by custom and demand. Packers reproduce exactly the representative sausages of many nationalities.

Between the stage of the manufacture when the spices and the meats are mixed on the rocker platform and the stage when the stuffing into casings takes place, there is a period when the product is allowed to cure, thus permitting the salt and the flavor of the spices to permeate the meat. Some varieties, such as Genoa and Lombardia, go back for further curing before roping. Stuffing is the next operation, after the meat has been chopped and cured and the casing selected and prepared. In the early days stuffing was done by hand, a slow and unsanitary method which made impossible a smooth, even texture or uniform shape and size. The introduction of up-to-date stuffing machines operated by compressed air, insures a well-filled sausage of attractive appearance, produced under sanitary conditions. Those styles of sausage that require a smoke flavor are subjected, after stuffing, to much the same process as are hams and bacon. Whether or not a sausage is smoked depends upon the trade for which it is intended. For instance, the people who have come from the northern countries of Europe prefer their dry sausage with a smoke flavor, while those of the Latin countries prefer it unsmoked.

The temperature of the smokehouse varies for different types of sausage. A variety in which pork predominates, for instance, cannot be subjected to the same degree of heat as one in which beef is the principal ingredient; for otherwise the pork fat would melt and spoil the texture. The degree of smoke also varies, from Gothaer, which is comparatively light smoked, to Göteborg, which is smoked heavily. Mortadella and Gold Band are not smoked, but are exposed to a high steam pressure, which sometimes gives a smoked appearance, though the smoked flavor is absent, and the result is a baked product. Whether smoked or not, however, the final step in the manufacture of all dry sausage is the drying by air. This is of vital importance, for the extent to which the drying process is carried determines in a large measure the quality of the product and the satisfaction which it will give to

the consumer. A gradual and thorough drying not only develops a better flavor, but increases the keeping qualities of the sausage, and to this end packers have equipped vast drying-rooms in which they can control both temperature and humidity. Here the sausage is frequently inspected on the racks, and is removed for twining and packing only when it has reached the exact degree of dryness demanded by the trade for which it is designed.

The last steps in the process of manufacture consist of twining and packing. Twining is unnecessary in so far as it affects the physical condition of the sausage. It is done simply to imitate the style and appearance to which various nationalities have been accustomed. It lends the national touch to the product. The Italian, for instance, who remembers the elaborate way in which Milan salami was twined by the sausage-makers of his native town in Italy, wants a product similar in appearance in this country. In lieu of twining, many styles are put up in parchment paper, tissue paper, or tinfoil. In some cases these package styles add to the keeping quality of the sausage. Last of all, the product is packed in boxes of various sizes and is ready for shipment. Every step in the process of manufacture is carried on under the guidance of a corps of United States government inspectors.

Dry sausage, as a whole, has excellent keeping qualities, its condition depending, of course, upon the amount of care and judgment used in storing. Dry sausage is shipped from the plants with three different degrees of dryness: (1) in a comparatively fresh condition, (2) medium dry, (3) fully dry. Some shipments of fresh and medium dry grades are made throughout the year, but from October to May the heaviest tonnage is on grades which are medium, or three-quarters dry. This is due to the fact that the fully dry grades can be made only in the winter, and until the first of May the product has not become dry enough to fall into the third class.

Sausage and sosera-in-oil are products which find a steady year-round sale throughout the South, and are in particular demand during the cotton-picking season. They are manufactured in three different grades, corresponding to similar grades of fresh

sausage; but for many purposes the oil product is preferable to the fresh sausage, because of its superior keeping qualities. Three grades of sausage in oil are frankfurts, smoked sausage, and bologna. The first two are more or less alike, except that frankfurts are of a fine chop, and, as a rule, are stuffed in sheep casings, while smoked sausage is of a somewhat coarser chop and is stuffed in hog casings. Bologna is similar to frankfurts in chop, but is stuffed in a beef round. For the three grades of sosera-in-oil which are sold as sandwich links, smoked links, and round sosera, practically the same distinctions hold good. Sosera-in-oil differs from sausage in oil in that it is a meat and cereal product.

The early stages of sausage and sosera-in-oil manufacture do not differ from those of the corresponding varieties of fresh sausage and sosera. The final stage, however, consists in packing in cans a certain weight of sausage to which a fixed amount of refined cottonseed oil is added. The top of the can is soldered tight, leaving only a small vent hole for the escape of such oil as may be forced out by the increased pressure during processing. The can is then immersed in a vat of oil which has been already heated to a certain temperature, and remains there until the required degree of heat is obtained in the center of the can, the purpose of this treatment being to destroy any bacteria that may be present in the product. The process followed is approved by the federal government experts and is carried out under their supervision.

Within the three sausage groups—fresh, smoked or cooked, and dry, or summer, sausage—there is a very wide range, including all the varieties of casings, together with loose sausage, packed in various ways. The meats used as the basis of all sausage include head meats of all kinds from cattle, hogs, sheep, and calves; lean trimmings from the hog-cutting floor; weasand meat, giblet meat, and the trimmings from the process of eviscerating all of the animals commonly slaughtered, heart-cap meat, hearts, livers, spleens (melts), and all of the products from the beef cutting and boning floor, with the exception of those marketed as cuts. In some cases fancy sausage includes all kinds of meats from prime hogs and cattle. In addition to these meats, cereal, eggs, spices,

and seasoning, and curing ingredients may enter into the manufacture of sausage.

The sausage business of American packers has come to be a world-business, as can be seen from the figures on the export and import trade for the year ending June 30, 1926 (Table XXI), as taken from the *Monthly Summary of Foreign Commerce of the U. S. Department of Commerce.*

TABLE XXI

SAUSAGE, ETC., EXPORTS AND IMPORTS

	Fiscal Year 1925 (Pounds)	Fiscal Year 1926 (Pounds)
Exports:		
Sausage, not canned	8,709,000	5,710,000
Sausage, canned	3,818,000	3,405,000
Sausage casings	39,972,000	34,615,000
Imports:		
Sausage casings	17,755,000	19,271,000

GROWTH OF SAUSAGE BUSINESS

The sausage business, both dry and fresh, is developing, due to the growing demand on the part of whole populations for ready-to-serve meats. This popular demand for sausage, which has been rising rapidly in recent years, has been brought about by certain definite causes·

1. The improved quality of the product. The tendency is always toward better sausage manufactured from finer-quality material, and the most successful manufacturer of sausage is the one who is constantly improving its quality.

2. Changes in the standard or method of living. With the ever increasing living in apartments in cities, people have come to rely more and more on delicatessen stores, a custom which has increased the consumption of ready-to-serve meats.

3. Increasing consumption of sausage among the better class of trade. Families of well-to-do business and professional men have been adding sausage to their diet. This is a trend which, though unnoticed by the general public, is of considerable significance, since it offers the best opportunity for expansion. The con-

sumption of sausage by the so-called "foreign elements" in our population is a relatively known quantity, but a greater consumption will soon be seen among the American constituents of our population.

4. The immense development of building and construction. Workers in this industry are accustomed to carrying their lunches to a degree much greater than in most other occupations. Sausage provides a ready-to-eat luncheon meat, both economical and appetizing. Taking the country as a whole, workers' lunches sustain a large and increasing outlet for this form of meat food. This outlet includes all factory workers, and is augmented in considerable measure by the demands of laborers during the harvest seasons throughout the agricultural regions.

5. Outdoor lunches. The development of the automobile and the national touring habit have created demands for wayside food and drink stands, which are now a familiar feature of the countryside. These stands serve meat sandwiches in large quantities, among them the popular "red hots." A similar outlet is found in huge athletic stadiums, where large amounts of sausage sandwiches are regularly dispensed.

6. Lack of waste in sausage. A final reason for the increase in sausage consumption is that people are coming to realize the economy of sausage as a food.

Standardization of Sausage

An element in marketing sausage which has an ever widening significance is the packaging of goods. The consumer looks for food in convenient and attractive packages. Therefore, the manufacturer who can supply his products in such packages is the one who is in a good position to increase his sales. The sausage trade of the meat-packing industry offers the principal opportunity for the use of attractive and artistic sales appeals, which has led to an ever extending use of package and carton. However, there is much to be done in standardizing packages, and also, from a strictly scientific point of view, in controlling quality of the product.

From a practical standpoint it is true that the manufacture of sausage has been standardized, as far as interstate commerce and certain intra-state trade is concerned, through government inspection. The federal meat inspection act provides for government control of sausage in interstate commerce, and laws of several states provide for the situation within their individual boundaries. As an illustration, the Pennsylvania laws prohibit the use of cereal and regulate the quality of materials, and are in line with the tendency of the industry itself in standardizing sausage content, packaging, and merchandising.

One of the great problems in merchandising sausage lies in the fact that government inspection is not universal. This means that packers complying with government standards in sausage manufacture must subject themselves to certain costs which are not borne by others unaffected by such inspection. Therefore manufacturers who do not comply with the government standards undersell inspected manufacturers, since their products are made from cheaper material.

Distribution of Sausage

In general, the distribution system for sausage is the same as that for other packing-house products. For dry sausage, the chief outlet is the butcher shop, with delicatessen and grocery stores constituting important distributive channels. In any particular locality the most significant outlet depends on the special trade conditions in effect. For example, in localities where the class of trade is predominantly Italian, the grocery store is the channel most used by the sausage manufacturer's sales department. In districts consisting of kitchenette apartments, the delicatessen shop is a valuable factor. For fresh sausage, the same outlets are used as for dry sausage, and the addition of wayside stands, etc. In both fresh and dry sausage distribution an important part is played by the jobber, and by the peddler truck, due to the degree of standardization in manufacture. In order to reach his final retail outlets, the packer makes use of his system of branch houses and car routes, of which the former account for

four-fifths to five-sixths of the total volume of trade. Until very recently car routes were used almost entirely for distributive work in territory near plants, serving principally small towns where there were inadequate facilities for keeping fresh sausage products. At the present time, with the widening scope of sausage consumption by native Americans, a gradual change is taking place.

It seems reasonable to assume that there are very sharp seasonal changes in sausage consumption. Pork sausage is largely eaten in winter, whereas other kinds are favorites in summer. In the fresh sausage business the total volume is relatively stable, but different kinds have their seasonal vogues. On the whole, there is a bulge in consumption in the summer and in the fall, in part due to a special increase in Italian demand. There is also a marked Easter demand for Italian (prosciutti) hams. These sharp increases in consumption are caused by the fact that Italians celebrate holidays most frequently by heavy eating. The autumn increase in consumption among all consumers is in part due to the seasonal habit of eating buckwheat cakes and syrup, accompanied by sausage. Again, in the summer the demand for ready-to-serve meats increases.

Some cyclical or seasonal changes in sausage consumption exist in relation to the supply of livestock. For example, when there are light runs of hogs, the sausage department will take all the heavy fresh hams and picnics (hams made from shoulders) it can obtain and will bone them out for sausage. The same is true of the dry sausage business. Big runs of hogs bring favorable prices in pork as a raw material for sausage, and displace other materials accordingly. When, on the other hand, the supply of hogs is short, their potential value becomes so great that it is not profitable to convert fresh hams into sausage. In case of a shortage of hogs, it is necessary to use high-priced sausage materials (as was seen during 1926) and to sacrifice profit to tonnage. The more the consumption of sausage increases, therefore, the less variable will be the channels of trade for sausage and the outlets for fresh pork cuts.

The number, kind, and quality of livestock marketed has another interesting effect, because the volume of cattle and hogs marketed influences directly the relative percentage of each material used in sausages. If, for example, a heavy run of hogs results in the price of pork falling below the price of beef, then the sausage business uses more pork in the manufacture of fresh sausage. This is also true, although in a more limited sense, of dry sausage, for in its manufacture standardized formulas are used which include definite proportions of beef and pork. Because of the heavy cattle runs of 1926, all sausage manufacturers have used more beef, since there has been a coincident shortage of pork. It will thus be seen that despite these variations in individual classes, sausage consumption is relatively steady when it is considered as a whole.

The geographical distribution of sausage throughout the United States reveals some interesting points and shows the growth of the sausage trade in various sections. These characteristics of the sausage trade can be summarized as follows: (1) The large sale of quality sausage, both fresh and dry, is in the big cities. (2) The most important outlet for the less expensive grades of sausage occurs in the South and Southwest. (3) Dry sausage is consumed in proportionately greater amounts in metropolitan centers than in the rural districts, while the condition is reversed for fresh sausage. (4) In general, sausage consumption is universal and increasing all the time. The per capita volume is relatively uniform throughout the United States, although the sections where foreigners form a considerable part of the population show a greater consumption because they have known sausage as a food for a longer time and understand its merits.

The chief merits of sausage are: (1) Sausage is a highly concentrated meat product. (2) It is a staple product, not dependent upon seasons or conditions. (3) It is a form of food lacking waste. In addition, dry sausage shows the following advantages: (1) It will keep almost indefinitely. (2) It requires no preparation.

The sausage business of today is of economic benefit both to packers and producers. From the point of view of the packers it

may be noted that: (1) The sausage trade gives an outlet for pork and beef material, for casings, and also for edible meat cuts and trimmings which, because of their size, cannot be sold in any other way, e.g., ham trimmings. (2) The manufacture of sausage offers the most profitable use of the cutting products of slaughter. (3) Sausage has wide and steady national outlets through every dealer in foods. (4) Sausage is not a foreign product. Its largest field of consumption is among American-born citizens, and its use is increasing rapidly to the advantage of the packer and livestock producer. (5) Sausage, both smoked and dry, has keeping quality, and this means that it does not have to be forced into glutted markets. Dry sausage, for example, can be made at times when sales outlets are slack and receipts of livestock are heavy.

From the point of view of the producer, there are several economic benefits flowing from the sausage trade. All of these can be expressed in terms of price, for the sausage business affords complete utilization by the packer of the meat products of livestock. This fact enables the producer to get a higher price for his cattle, sheep, and hogs. In addition, the existence of the sausage business, with its steady permanent character, makes for the stabilizing of livestock prices. In this indirect but fundamental way the sausage business is an economic benefit to the livestock producers of the United States.

Other Cured Meat Products

Though sausage constitutes a great part of the outlet for cured meats, there are many other forms of cured meat products which are not, of course, strictly speaking included among by-products. However, to make the product treatment in this book comprehensive, a brief discussion of cured meat products is given here. This is of special interest to students of the business because meat curing was the early foundation of the meat-packing industry, the livestock being slaughtered in cold weather and cured so that the meat could be held and sold in warm weather. The growing popularity of smoked meats has been an aid for increasing meat consumption. In curing meats they must be preserved against

spoilage through bacterial decomposition, by being put in a strong salt solution, or by packing in salt. Curing imparts a distinctive flavor and aroma resulting from a blending of the flavors of curing ingredients, e. g., salt and sugar, and smoke, aided by the mellowing action of bacteria, as in butter. Proper handling keeps the natural color and includes sanitation by sterilization, quick removal of animal heat, and chilling in dry coolers.

Meats are cured by three methods, viz., sweet pickle, dry salt, and dry sugar cures. Among those meats which are sweet pickle cured are hams, picnics, shoulders, bellies, and tongues. Most export cuts are cured by the dry salt method, and these include Cumberlands, long clears, square shoulders, English bellies, long-cut hams, and bacon. In curing hams by the sweet pickle process, the pickle, a salt solution of desired strength to which is added sugar and saltpeter, is put in a pumping barrel, which is equipped with a force pump, connected by means of a hose through a perforated needle. This needle is injected into the shank, or the butt of the ham, near the bone, and a vigorous stroke is given to the ham. By this means the pickle is forced into the ham, and penetrates the meat. The hams are then properly packed in tierces to insure proper circulation and to preserve a good appearance. At stated intervals hams are overhauled, i.e., transferred from one vat to another, when cured hams are taken from the pickle solution, drained, and put in the smokehouse, where they are soaked before smoking. This method, with certain variations, applies to all sweet pickle curing.

While there is not as much risk in curing boneless or dry salt meats as in the sweet pickle process, very great care is necessary. By this process the green meat is covered with a light coat of good pure clean salt, after which the dry salt meats are placed in piles, with as few air spaces as possible. At intervals of several days the meats are overhauled and repiled with fresh salt. A fancy dry cure is often used for bacon because of its wide popularity. "Dry," "fancy," or "box" cured bacon is cured by placing it in boxes, using about 5 lb. of dry curing ingredients to 100 lb. of green meat, and depending upon the moisture in the meat to dissolve the salts and to effect penetration into the interior of the bellies.

PUTTING HAMS IN CONTAINERS FOR COOKING

PACKING SLICED BACON IN JARS

Very little beef is cured, compared with the quantity of cured pork, but beef hams are often cured and smoked for production of dried beef. Indeed, although brine beef, unlike pork, is marketed for the most part in fresh sides and quarters, there are periods when, due to higher values of certain beef cuts, beef carcasses may be cut up into workable cuts, in order to bring a greater yield to the packer. At such times it may be profitable to provide an outlet, by curing, for some of the cuts in lesser demand. Among the most important cured beef products are corned beef, made from the plate or rump, which has been popular since early New England days, barreled beef, dried beef, cured beef tongues, and pressed ox tongues. In general, most meat specialties may be subjected to a dry salt cure.

The third method, which has come more and more into practice during recent years, is the dry sugar cure. This applies mainly to the light fancy bacon and other cuts requiring a mild cure. It consists of packing the meats very tightly into watertight vats holding from four to six hundred pounds, with a sprinkle of salt, sugar, and nitrate, or nitrite of soda between the layers of pieces, and leaving the meats in this condition to cure in their own juices.

The final step in the curing process of smoked meats is the smoking of the meats over a smoldering fire fed by hard wood. Smoke deposits a thin coating of creosote on the surface of the product, which contributes to its preservation and, at the same time, imparts a flavor to the pork which cannot be obtained otherwise. The smoking process generally takes place shortly before the product is marketed, and near the place of sale, so that the product reaches the trade with the "bloom" of freshly smoked meat.

Standardization

The advent of the chemist and his laboratory control have made possible the curing of meats on a large scale with a uniformity hitherto unattainable. The modern cured product turned out under the guidance of chemical laboratory control is a standardized product. Hams and sides of bacon are classed in various sizes or trade averages, as follows: 6–8 lb., 8–10 lb., 10–12 lb., 12–14 lb., 14–16 lb., etc. These averages are, in turn, divided into grades

which consist of the fancy cuts and one or more standard or competitive cuts. The fancy grades come from young grain-fed hogs. The meat has a smooth grain and a delicious flavor. Only those cuts which have the right contour, perfection of trim, and the proper amount of fat are selected for this grade. The dry sugar cure that is given these cuts produces a mild, sweet, and uniform flavor.

Smoked meats occupy a very important part of the packer's attention. By quality and fancy grades of ham and bacon, a packer builds up enough prestige so that the quality and reputation of this brand will carry over into such lines as sausage, canned meats, and other of his branded lines. A packer stakes his reputation for handling quality products on the kind of smoked meats he produces. Therefore, it is natural that various steps are taken by the packer to minimize the possibilities of his smoked meats reaching the ultimate consumer in poor condition. Smoked meats are sold on a week-to-week basis in order to guard against the accumulation of old stocks in the hands of the dealer. In reducing deterioration in the dealer's shop, the packer has developed a careful and efficient method of wrapping smoked meats. A large percentage of these products is wrapped in a parchment paper, which aids materially in keeping down shrinkage and deterioration. One concern uses a stockinet in addition to regular wrapper in its fancy grades of hams. A special preparation is applied to the outside of the wrapper of smoked meats going to tropical countries. The outside coating of the preparation applied to regular wrapping, seals the product airtight so that it keeps in a fresh condition.

Smoked meats are semiperishable products. Consequently, it is not so necessary to alter prices to move a surplus of production as in the case of the more perishable lines. Prices of cured meats are much more stable than those of fresh pork, beef, and mutton, because these products have to be forced into consumption during times of glutted markets. In general, prices are lowest from November to February, and highest in the summer. This is partly due to the fact that the housewife buys more meat to fry in the summer, thus creating an extra demand, with resulting higher

prices. This condition is also due to the fact that cured meats are less perishable and more in demand during the hotter weather. Prices are lower in the winter because of the increased demand for fresh pork.

Smoked meats are sold by all classes of meat markets, and are more generally included in the stocks of grocery stores than fresh meats on account of the differences in perishability. Hams and bacon also find a ready market in hotels, clubs, restaurants, dining cars, steamship lines, fairs, carnivals, and tourist camps. They are in greatest demand in the 8–10 lb. average and the 10–12 lb. average, and should be smooth, meaty, and of fine firm texture. The plump little ham is most desired, although the trade will take a long shanked ham if it conforms to other qualifications. For some classes of trade 12–14 and 14–16 lb. hams are more desirable, the latter being especially demanded for sale as sliced ham. The large and fat hams are skinned and trimmed, and sold to the trade as skinned hams. Picnics are not so fancy as hams and are sold at a lower price. They find their principal market in geographic areas where price is a factor, such as the rural districts and the southern markets. They are also exported in large quantities to Europe.

In most markets the medium lots of bacon, i.e., the 6–8 and 8–10 lb. averages, are the most popular. The city trade ranges from 4–6 to 6–8 lb. cuts. The Eastern trade (with some Chicago demand) are 8–10 and 10–12 lb. averages. In New England, where bacon is used for larding and boiling purposes, 10–16 lb. pieces are in demand. The heavy 16–25 lb. bellies go to outdoor camps and to southern markets.

Edible Fresh Beef By-Products

Edible beef and sheep by-products, or specialties, are in great demand, and include beef-, sheep-, and calf-head meats, sweetbreads, tongues, weasand meat, hearts and livers, beef spleen (melts), tripe (regular and honeycomb), kidneys, and ox tails. Of these products, ox tongues, calf livers, and sweetbreads are quite valuable, and kidneys and livers are rich in food elements. All of

the departments in which meat specialties are prepared are operated under rigorous sanitary conditions. Beef tongues are removed carefully, hand-washed, drained, and chilled for some twenty-four hours. There are three classes of finished tongues: Canner tongues, which include the pendulous, fleshy portion of the tongue; short-cut tongues, which, are trimmed free of the trachea or windpipe, and leave one-half of the tissue of the base on the tongue root; long-cut tongues, which are the rough tongues free

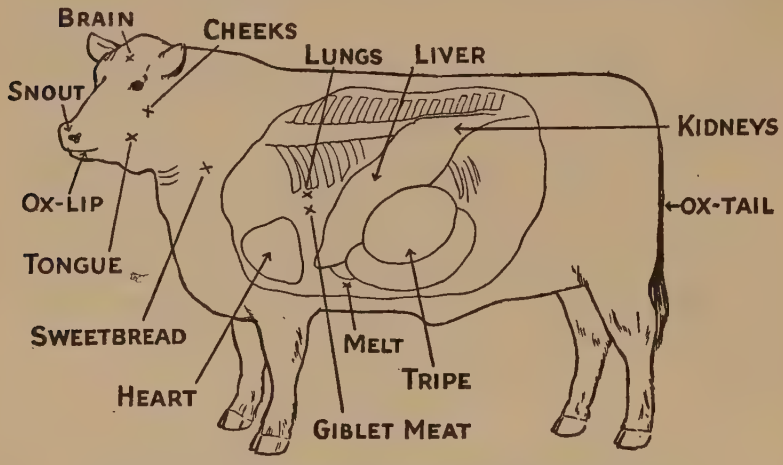


FIG. 39.—Edible beef products (other than fresh beef cuts)

of bones, trimmed smooth on sides and butt, without any of the trachea attached. Tongues are sold fresh or cured, or stored in freezers awaiting sale. The trimming meat is used in sausage and the trimming fats in oleo oil.

Head meats, including cheek meat, are used in the making of fresh and dry sausage. Brains are usually sold fresh in boxes or in cans. The yield of meats from the various parts of the head depends upon current general market conditions and upon the skill in separating the parts after the most profitable disposition has been determined upon. Beef livers require expert handling in removing all fat and the gall bladder (from which the valuable gall stones are taken), but as in the handling of all meat specialties,

the use of water is held to a minimum. They are often dried, chilled, and frozen in this condition, and held for sale.

The pluck consists of the heart, lungs, and trachea. There is very little trimming of hearts, if there is a heavy demand for them, which would tend to make heart values greater than the value of the possible yield of oleo oil from the trimmed fat, plus the cost of recovery. The pluck fats go into oleo, and the lean tissues into sausage.

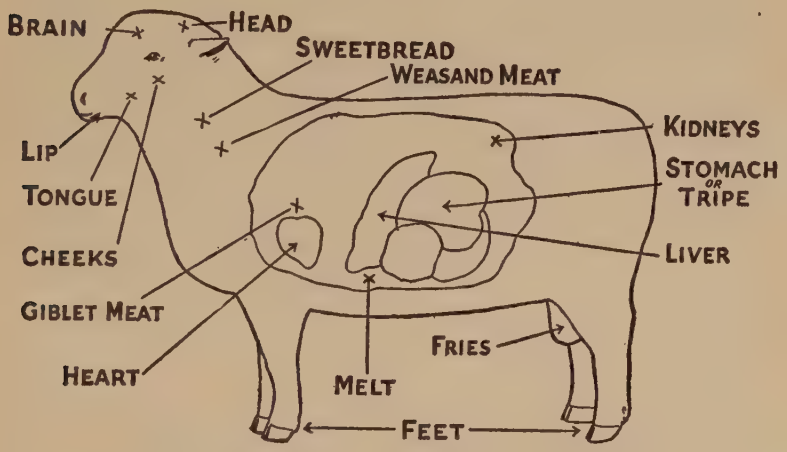


FIG. 40.—Sources of medicinal products from sheep

From the ruminant stomach comes the meat specialty known as tripe, which consists of the walls of the first and second stomachs. Before sale, tripe is thoroughly washed and trimmed and chilled, after which it may be sold fresh, pickled, or cured. For use as crab bait, tripe is prepared in a special manner. From trimmed weasands is made weasand meat, which is handled in a manner similar to head meats, or is packed in tierces, after being sprinkled with salt and nitrate of soda. Sweetbreads are cut out on the killing floor, are immersed in cracked ice or iced water, and held in a cooler for several hours or frozen before shipping in crushed ice. Beef or ox tails are marketed fresh, are used in canning, or are marketed frozen. Oxtail soup has long had a high reputation among epicures.

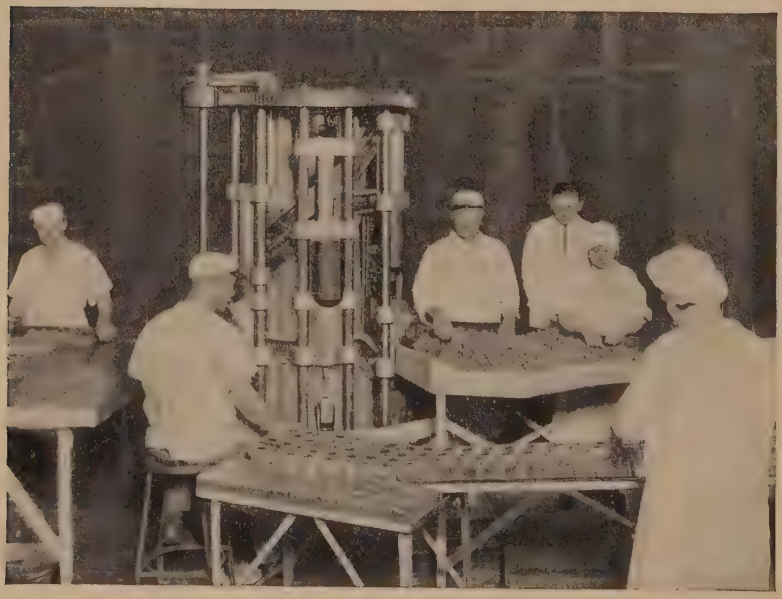
There are several channels for the disposal of meat specialties. They are packed for shipment fresh, or for freezer storage, for export shipment, or are transferred fresh to the sausage, canning, and curing departments. In the preparation of all meat specialties, one of the most important matters is the control of the yields, because on accurate determination of yields of various products depends the decision of profitable policy. This control and checking of yields takes place in the meat-specialty cooler.

A useful beef by-product is beef extract, one of the earliest by-products, developed as a result of the research of the noted German chemist, Justus von Liebig. It consists of the concentrated cooking waters from the heating of beef in the course of the process of canning. This cooking process results in much protein, so necessary to human life, going into solution. When concentrated by evaporation under vacuum, the resulting liquid obtained (beef extract) is rich in the best food elements of beef, and is stimulating, easily digested, and very palatable. Beef extract is sold in solid form as the basis for various fluid extracts and bouillon cubes, broths, and soups.

Meat Canning

The last products to be considered are canned meats. The preservation of meat and meat products is undertaken in three ways. The first method, that of desiccation, or drying, was resorted to by all primitive people for the preservation of meat in order to hold it over from times of plenty to times of scarcity. The early method of desiccation is reflected in the present-day practice of smoking hams and bacon, as well as in the manufacture of dried beef. The second method of preservation is curing by means of salt and other ingredients, whereby bacterial action is reduced through impregnation with salt. The third and most effective method of preservation is that of absolute sterilization, which can be achieved only by cooking meat and meat products at such a temperature that bacteria are destroyed, and by sealing the product in cans, preferably under a vacuum, to eliminate any possibility of further development of destructive organisms. Under such

READY-TO-SERVE MEAT PRODUCTS IN STORAGE



FILLING CANS OF CORNED BEEF

circumstances meat products remain sweet and in good condition indefinitely.

The canned meat department is a necessary and important adjunct to any large meat-packing establishment. An outlet of this nature is likewise essential to small packing plants. Although they may not have an output sufficient to justify the expense of maintaining a canning department and organization of their own, they can dispose of their fancy meat products to other canning establishments and obtain a fairly good return for them. Every animal yields meat by-products that can usually be profitably utilized in a canning department. The keeping quality of canned meats enables a packer to supply roast, corned, and other canned meats to the explorer, sailor, soldier, and pioneer; and there is a large demand for these convenient articles of food, not only in distant places that lack the means and facilities to keep fresh meats in good condition, but also in large centers of population. The reason for these nutritive foods being in steady demand is that as an emergency article of food the canned product is supreme. A canned meat department, therefore, must be looked upon as a necessity in the organization of every up-to-date packing plant.

The largest item used for canning is beef trimmings. Indeed, the canning department shares with the sausage department the use of these products. Small trimmings of both beef and pork are used for potted and deviled meats, and form a very important luncheon food for workers in mills and fields. The canning department comes to the aid of the sausage department in absorbing a large part of its output by canning the sausages and making them into a product that will keep almost indefinitely and under any climatic conditions. For example, large quantities of viennas or frankfurts are handled in this manner yearly. Thus, through the medium of potted and deviled meats, viennas, etc., an outlet is found for small trimmings, tripe, and fancy meats.

Until a few years ago, as soon as the weather became warm each season, fresh brains of all kinds—beef, hog, and sheep—went to the fertilizer tanks, if they could not be sold fresh, and the financial return to the packer was virtually nothing. Today they

are used in the canning department and bring a fair price; and indeed, the demand for brains has been expanded so that during the cold weather, when this delicate fancy meat can be safely shipped, the supply is more readily absorbed than formerly, and at better prices.

A canning department, when properly administered, is well equipped, and the operator or executive superintendent knows his business. For example, he realizes that too much cooking will run away with the profits; too little will spoil the product. The labor force must be handled efficiently, and a fair proportion of the men must be familiar with the operations, or serious trouble will occur. Canned meats must be put up in the factory in a clean and attractive manner. Lastly, canned goods must be skilfully distributed by the sales department at a price in excess of the cost plus all overhead and selling expenses. There is a difficult marketing problem in fresh meat by-products, for although there is always a demand for them, the supply usually exceeds the demand. However, the canning department can use this surplus of fresh by-products very well. For example, tongues—beef, hog, and sheep—are canned and sold as ox tongue and luncheon tongue, and chucks, regular beef trimmings, cheeks, weasand meat, tripe, kidneys, livers, shank meat, pigs' feet, palates, pig snouts, and pig heads are used daily. The packing of bacon and dried beef in glass jars or boxes is an operation usually allied with the canning department, as these products are marketed through the same trade channels.

The canning department broadens greatly the packer's field of trading operations. Its products are a necessity at times to those whose lives are spent off the beaten paths, making it possible for them to have foods that are nutritious and appetizing.

Operation of a Meat-Canning Factory

Many meat materials to be canned are first cured. These meats which are cured are packed in hogsheads and covered with a pickling solution. The time of curing varies from 18 to 50 days, and after curing, the meat is transferred to the kitchen to be

cooked. In this first operation in the canning factory, the packer makes careful selection of a proper cooking vessel, for the following reasons: first, it should be composed of a material that will not impart flavor to the product; second, it should be of such shape that the material to be cooked may be easily and conveniently handled and that heat may be properly applied; and third, it should be easy to keep clean. The best material for this purpose is glass-lined steel; next is aluminum, and third, tin-lined copper. Cast iron or steel kettles also are used.

The material to be canned is cooked in these kettles only enough to enable the meat to be properly trimmed, and therefore the time of cooking varies from 15 minutes to $1\frac{1}{2}$ hours, depending upon the size and nature of the material. Trimming consists in cutting away all gristle, imbedded bone, and surplus fat. Cooking should always be preceded by careful selection of the product, and the proper cooking itself is as necessary in the canning factory as in the home or in the hotel kitchen. The supervisor of this cooking operation is almost a "chef." He produces the greatest possible yield from the product at hand. In cooking beef, the residual water may be profitably concentrated as beef extract, or it may be prepared as broth or soup, in both cases a product flavored to suit a discriminating public. After the meats have had such a preliminary cooking and have been trimmed of gristle, imbedded bone, and surplus fat, they are put through the machines which cut them into properly sized pieces, except in the case of the canning of whole pieces, such as tongues, where the pieces are sorted to the proper sizes.

The product is next discharged into stuffing machines, which deliver a certain weight into each can. As soon as the product is in the cans they are automatically conveyed forward to a sealing machine where the tops are double seamed. The old-style can with its soldered top is gradually being replaced by the so-called "sanitary style," owing to the fact that the latter requires less handling because of its mechanical construction. When "sanitary" cans are used, the air is extracted by one of several systems, as follows: (*a*) The vents are closed and the cans are given a partial processing.

They are then reopened to permit the air to escape, after which they are again closed and put through the balance of the process to sterilize the products properly. (*b*) In the cold vacuum process, the cans are sealed with the vents left open, are passed to the vacuum machine, and the vents are then closed. This process varies considerably owing to the nature of the product and the size and style of the can. (*c*) Another, or hot, process system compresses the meat in cans as much as possible, and passes them through a steam exhaust box. The length of time necessary for the cans to remain in the steam exhaust box in order to exhaust the air is governed by the size of the can and the nature of the product. Usually the meat is heated to 160° F., and is then passed as quickly as possible to the closure machine, which hermetically seals the can. The can is processed and put under a cold-water shower to cause the ends to collapse.

After the heat processing, the cans are chilled and inspected for leakers, and conveyed through the washing machine, which is arranged in such a manner that the cans first encounter a bath of strong, hot (212° F.) caustic water, which cuts off most of the grease adhering to the cans; next, they pass through a tank containing water heated to 200° F., which removes the caustic water; and finally, they are sprayed with cold water. The cans are then sent to the labeling-room, where labels are automatically pasted upon the outside of the packages. The last operation is the packing into cases, when they are ready to enter distributive channels. In the case of export products, it is necessary to lacquer all cans in order to avoid rust from the dampness of an ocean trip. After the cans are painted, they are boxed, and great care is always exercised in nailing on covers to avoid puncturing any cans.

At several points in the operation of canning, individual cans are inspected for leakers. This is important, because the slightest infiltration of air into sealed canned goods causes spoilage dangerous to the health of consumers. The first inspection is after the initial sealing. In the case of soldered cans, this consists of an examination of the can and the proper application of the solder to the cap. In the case of double-seamed tops, it involves an inspec-

tion of the proper performance of the double-seaming. From this point on, the examination of both types of cans for leakers is the same.

After the cap has been soldered on, the can is placed in a vacuum machine and the vent hole in the cap is sealed while the can is under vacuum. Again the cans are inspected for leaks, which may consist of vent leaks, cap leaks, seam leaks, or body leaks. Another inspection is made after processing in the retorts, and the final inspection of the cans is given after they have been run through the washing machine. This inspection is for what is called "slow leaks," i.e., leaks which do not show up immediately; the cans, therefore, have to be stored for a short period to allow these leaks to develop.

The processing of canned meats has developed a standard practice in the industry regarding such matters as length of time and temperature used. However, the quality, and especially the healthfulness and keeping qualities of the product, can be greatly affected by the process of going wrong because of the failure of some checking device or control. For example, it is necessary to have all air removed from the retorts, if pressures and the temperatures are to be relied upon. Automatic control and recording devices of both temperature and pressure are used. The charts on which these records are kept are identified with the date and the cans of goods processed. These recording devices and pressure gauges are frequently inspected and checked up against mercury thermometers, or carefully calibrated thermocouples. The cans used are coded with a marking device which permits identification of a day's run, or part of a day's run. This coding permits the withdrawal from the market of any goods which are causing trouble, thus protecting the consumer and keeping the confidence of public health officials.

The price level of canned meats is probably the most stable of any items in the meat trade, largely due to the non-perishable nature of the product. Therefore, it can be sold safely for future delivery. Quantity discounts can be made because there is little danger of price changes. Evidence of quality is that cans are full

and contents firm and solid. Therefore cans contain little or no excess moisture, and preserve the natural color and flavor of the meat. The principal outlets are meat markets, grocery stores, delicatessens, restaurants, hotels, and cafés, construction, lumber, and tourist camps.

The northern and southern markets buy principally corned beef, lamb and ox tongues, and luncheon beef. Sliced, corned, or luncheon beef makes an appetizing cold luncheon, and is sold to tourists and picnic parties. Corned beef is also sold in large quantities in rural communities where fresh meat is not available in the summer. Tongues are sliced and served cold, or used as sandwich filler, and for picnics, parties, etc. The south is the chief domestic market for canned foods. Most of the demand is for potted and deviled meats, vienna style sausage, tripe, and brains. The negro trade is a heavy buyer the year round, but especially during the cotton-planting and picking seasons, when negro purchasing power is at its height. There is a year-round demand for most lines of canned meats, with extra demands during the crop-planting season in the spring and the harvest in the fall.

The principal foreign markets for canned meats follow:

EXPORTS OF CANNED MEATS FROM THE UNITED STATES*

	Percentage
United Kingdom	85.59
Italy	4.0
Canada	2.2
Belgium	1.3
West Indies	.5
Germany	.5
Sweden	.4
France	.2
Others	4.7

* Total amount exported, 2,801,000 lb.

The United Kingdom furnishes the principal export market for canned meats. Large quantities of corned beef, potted meats, and luncheon tongues are exported for English consumption. Indeed 80 to 90 per cent of the luncheon tongues produced in the United States are exported to the British market. Exported trim-

mings and potted meats are made into meat pastes by the English on a very significant scale. This total trade is of very considerable proportions.

Among the various canned products are corned and roast beef, boiled beef, sliced dried beef, sliced bacon, cooked ox tongue, cooked luncheon tongue, vienna style sausage, pork sausage, corned beef hash, roast beef hash, boneless and jellied pigs' feet, hamburger steak with onions, cooked brains, stewed kidneys, chili con carne, extract of beef, and bouillon cubes. All of these products are put up in a complete range of sizes of cans, and represent packages most convenient for the requirements of consumers. The use of canned meats has become widespread in all parts of the world because they represent a direct trend toward economy.

CHAPTER IX

CASINGS, STRINGS, AND LIGATURES

Due to the rapid increase in sausage consumption, hog, sheep, and beef casings have become very valuable by-products of the packing industry. Casings have long been used as containers in the production of sausage. Manufacturers in different parts of the country bought them directly from packers, who for a long

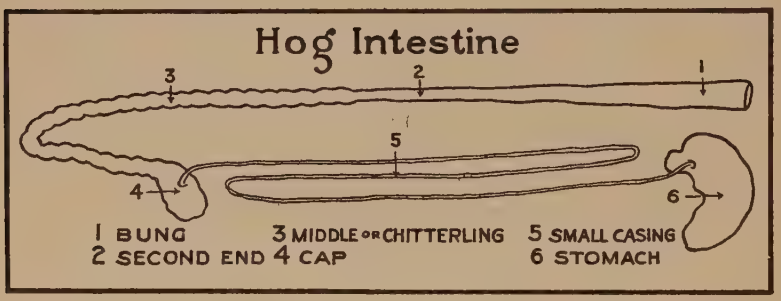


FIG. 41

time were so concerned with supplying the increasing demand for fresh meat, that they ignored the sausage business and did not even process the casings they produced themselves. The national volume of trade created by smaller sausage-makers soon provided such desirable outlets for this type of by-product that the national packers established fully equipped casing departments as integral operating parts of their businesses. In spite of this attention to domestic casing production, however, the demand today can only be met adequately by importing great quantities of narrow casings (sheep and hog) from the Orient. Because of the relatively high price of ordinary casings, other types of containers are continually being sought. This rapidly growing demand for sausage casings provides an accurate index of the increase in sausage consumption.

VARIETIES OF SAUSAGE CASINGS

Regarding the uses of different casings, in general, sheep casings are used for fresh pork sausage and frankfurters; hog casings are used for fresh sausage, such as frankfurters and pork, and also for chorizos, which is sold largely in the Spanish trade, including Cuba, Mexico, and South America; and beef casings are used both for fresh and dry summer sausage, e.g., for luncheon meats and bologna, and for dry summer sausage, B.C. salami, etc. A more detailed statement on the uses of different types of casings is shown in the accompanying tables.

DRY SAUSAGE CONTAINERS: HOG INTESTINES

1. Bung
   - Summer sausage (or Cervelat) (all grades)
   - Gothaer (all grades)
   - Milan (all grades)
   - Arles (all grades)
   - Lyons
   - Alessandria
2. Second End
   - Menage
   - Salamini Corté
3. Middle
   - Sopressata
   - Frizzes
4. Cap End
   - Alpino salami
5. Small Casing
   - Landjaeger
   - Austrian pork
   - Italian pork
   - Chorizos
   - Caserta peperoni

DRY SAUSAGE CONTAINERS: BEEF INTESTINES

1. Fat End
   - Not used
2. Wide Middle
   - Salami B.C. (German)
3. Narrow Middle
   - Göteborg
   - Farmer
   - Nola
   - Arles
   - Sicilian salami
   - Bobbio
   - Summer sausage
4. Bung
   - Summer sausage
   - Salami
   - Lebanon
   - Coppa
   - Cappicolli
   - Salami cucinato
5. Round
   - Holstein
   - Mettwurst
6. Bladder
   - Mortadella

Principles of Casings Handling

Hog casings are derived from a series of intestines which, when the hog is eviscerated, are enmeshed in the ruffle fat, whose func-

tion is to keep all organs in place in the live animal. Since the invention of the hog-casing cleaning machine, these casings have been easily saved and handled. Yet careless pulling and cleaning of this delicate material decreases the value very quickly. Therefore, a casings department has three main principles to guide it in its operations with all kinds of casings, hog, beef, or sheep. These principles are: (1) the obtaining of the greatest length of casing consistent with a quality product; (2) the obtaining and preservation of an attractive color; (3) the guarding against sourness, overfermentation, or spoilage.

In achieving these three ends there are two problems to solve satisfactorily, viz., (1) the cleansing of casings so that refuse and dirt are thoroughly removed; (2) the prompt elimination of heat in order to prevent decomposition from bacteria and overfermentation.

The process by which these aims are accomplished is curing, for after speedy cleansing and chilling, casings are packed in salt or in saline solution and held until thoroughly cured.

Processing Hog Casings

When hog casings are pulled from the ruffle fat the ruffle fat is left as much as possible in its entirety, and care is taken to prevent scoring or breaking of casings while pulling. When ten sets are pulled off, they are tied together and delivered to an operator called a stripper, who strips out the refuse. This is usually done by hand through closing down upon the casing, flattening it out, and running it so as to force out the refuse, or by means of a mechanical stripping machine. After the refuse is completely forced from the casings, they are put into a wooden tub or box filled with cold water, and remain there long enough to remove the heat, which takes about twenty minutes. The temperature is not to be higher than 50° F., and may well be lower. This corresponds to the removal of heat from the carcasses in the hog cooler. But with such a small product, cooling is accomplished more quickly, simply, and easily. When the casings are removed from the water a knot is tied in the center of the casing, and five

bundles of fifty sets of casings are put into each tierce. They are soaked in water at above 70° F. overnight, or until fermentation of the mucous and muscular coating of the casing wall is completed. Overfermentation, however, will soften the casings. Again the casings are stripped of the fermentation product developed during the time of holding in water. This is accomplished by hand. After fermenting and stripping the casings are soaked for about one hour at 100° F., and stripped again, allowed to stand for another hour, and then stripped finally before putting them through the cleansing machine. A hog-casing cleansing machine is composed of numerous cylindrical rollers and knives, by means of which the final contents of the casings are effectively removed.

After the casings are run through the machine to remove all of the dirt left on the inside, they are placed in a mild, well-iced salt solution of some 15–20 degrees pickle, and are held thus overnight. The next day they are delivered to the grading tables, where they are graded for width by expanding with water and measuring the true width. All holes larger than a lead pencil are cut out and squared. The four accepted grades are: (1) narrow, which includes all casings up to $1\frac{1}{8}$ inches wide; (2) narrow medium, including casings with a width over $1\frac{1}{8}$ inches and including those of $1\frac{1}{4}$ inches wide; (3) medium, including all casings over $1\frac{1}{8}$ inches to $1\frac{3}{8}$ inches wide; and (4) wide, including all casings over $1\frac{3}{8}$ inches wide. Considerable extension of grades is made by packers having a demand for narrow, mediums, medium wides, etc. In measuring for length, a number of lengths are kept together, e.g., shorts, mediums, longs, etc.

Casings under 6 feet in length, which are known as stump casings, are packed as No. 1 and are sold as such. The sorted lengths are sometimes made up into bundles 300 feet in length, averaging nearly 20 feet long as a minimum, with an allowance of 2 per cent for shrinkage in salt. Measurement is sometimes made in cans about 5×5 inches, but linear measurement is better. At present, however, the best practice is that by which the hog casings are sold on a measurement basis of the same kind as that on which

sheep casings are sold. After being made up into bundles, casings are dipped and rubbed in medium fine salt and placed in a bin with a perforated bottom, where they remain until they have had an opportunity to drain and cure fully.

When removed from the curing bin, the medium fine salt is shaken out of the casings and they are thoroughly rubbed with fine salt until they have absorbed 40 per cent of salt. They are then packed into barrels or tierces holding about 300 bundles of hog casings, and are ready for use or for shipment. A method of handling casings is now quite widely known, by which the fermentation of casings takes place in brine instead of in water. It is claimed that this method eliminates much of the objectionable odor in casing departments.

As hog bungs are connected with the black gut, it has been found that, when pulling the hog bung from its setting, the skin must be broken over the casing leading to the black gut. After the bung is pulled from the encased fat it is tied with twine at the end leading to the black gut, in order to keep the refuse away from the ruffle fat. It is then taken off from 5-feet lengths up, and is delivered to an operator who trims the fat around the crown, after which the casing is blown for width and graded. On being blown, it is turned inside out and chilled in ice-cold water, each width being kept separate. As a rule the widths into which bungs are graded are export, prime, special prime, narrow prime, and small prime. These casings are salted, ten pieces to a bundle, and packed into tierces.

Hog bladders are blown with air so that the fat may be trimmed away from them. Like all other casings, they are thoroughly chilled with water while processing, and are then either dried or salted, and graded as follows: 5–7, 7–9, 9–11, and 11 and over. However, some small bladders are sometimes saved and used for containers for export lard, averaging about $3\frac{1}{2}$ lb. to the bladder. The numerals used in describing the grades are descriptive of the weight of the contents of the bladder when used as a casing.

Hog middle guts, known as the black gut, or chitterling, run

from about 12 to 14 linear feet, and average about 5 lb. They are frequently sold as an edible product, especially to the negro trade as chitterlings only. In preparation the gut is first spread apart from the fat, the fat is trimmed off, the gut is flushed out, turned, and is kept in cold water until the next morning. Then it is bunched five sets to a bundle, thoroughly salted and drained overnight, and finally resalted and packed in tierces. Hog stomachs are trimmed free of all fat, thoroughly cleaned and washed, turned inside out and thoroughly slimed. When used as a casing, the stomach is preserved intact, and after thorough cleansing and sliming, it is packed in salt in a tierce with a perforated bottom. It is then allowed to drain overnight, or to remain in salt until thoroughly cured, when it is ready for use as a container for sausage, especially head cheese.

Beef and Sheep Casings

The basic principles in processing beef and sheep casings are those governing hog casings. Both are used as food containers and must be processed in a sanitary manner. The intestines of sheep are valuable and command a very high price, for the American consumer prefers sausages of a diameter of from 11/16 inch to 1 inch, and thus there is a big trade demand for narrow casings. After the sheep intestines are delivered to the casings department, the blind end which has been separated on the killing floor is thoroughly washed on the outside, and turned inside out. After salting and drying, these are known as "caps," and are in considerable demand by pharmaceutical supply houses.

The small intestines are next pulled free from the enfolding ruffle fat, care being taken not to break or score the intestinal walls, or to leave any fat upon the intestines.

After pulling, the intestines are stripped free of their contents by running them through between the operator's fingers, thus squeezing out the contents. This stripping is repeated a second time to eliminate the foreign matter completely. The intestines are tied, hung on sticks in sets of ten, immersed in a tierce of cool water at a temperature of about 50° F., and held there until the

mucus on the muscular tissue is fermented, or softened, to such an extent that it may be handled by a cleaning machine. This usually requires 12–14 hours, although the process may be shortened by the use of warm water so that the intestines can be handled in the same way.

For cleaning purposes, sheep intestines are run through a casings-cleaning machine, between the rolls, to remove the mucus. The only difference in cleaning sheep and hog intestines is that a spray of lukewarm water is played upon the rolls while cleaning

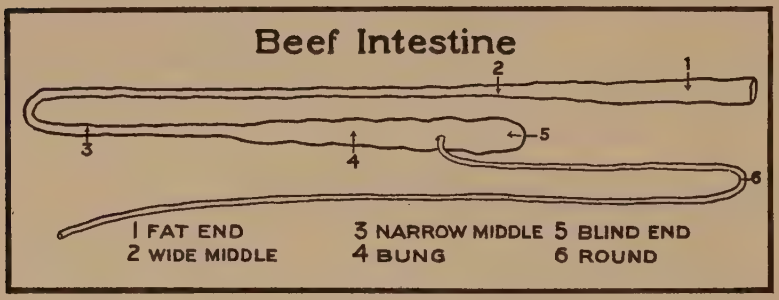


FIG. 42

the intestines of sheep. Thorough cleaning usually involves running the intestines through the machine a second time, by which time they are termed sheep casings. After this they are thoroughly chilled in iced water, or mild pickle solution, and are delivered to grading tables, where they are inflated with water, measured for width and length, and selected for various grades.

In a general classification of sheep casings, pieces under 6 feet in length are not allowed in any classification. Table XXII gives the classification most generally adopted throughout the country, although there are various modifications in some plants.

The grading tables are kept clean to a point of absolute sterilization, and are smooth and free from any rough places or projections which might possibly injure the walls of the casings. On being graded for diameter, the casings are measured, and because of high prices which they command, great care is used in measuring. If "long" measure is given it will be reflected sharply in the money

yield, and if "short" measure is given, there will be dissatisfaction among customers. After they are made up into bundles, casings are dipped and rubbed in fine salt. They are then packed into barrels and tierces, and are ready for use or shipment without any further processing.

Sheep casings are very tender, and their value requires special care throughout the process of handling. The intestines are guarded carefully in the opening operation on the killing floor, for the incision should not be deep enough to cause puncturing. Stripping is very exacting, because the contents of the intestines must be

TABLE XXII

Classification	Diameter	Length of Hank (Yards)
Narrow	Under 11/16", or under 17 mm.	125
Small mediums	11/16" up to 13/16", or 17–21 mm.	115
Mediums	13/16" up to 15/16", or 21–24 mm.	100
Wide	15/16" and over, or 24 mm. and over	90

cleanly removed, and must not be broken by such foreign particles as cinders, glass, or any other ingesta. The muscular tissue is so light that only slight fermentation is necessary to render the intestines ready for final cleaning, but in running through a machine great care is shown. Proper supervision pays the packer well, and two supervisors may obtain very different yields. Constant vigilance is needed to produce the greatest yield, and to preserve at the same time the most attractive color. In the department where the intestines are separated from the enfolding fat, the supervisor sees that all of the fat is retained, and much care is exercised to prevent waste through the escape of product into catch basins, where, even if recovered, it loses a considerable part of its commercial value.

The Gut-String Industry

The gut-string industry originated in Italy, according to common report, and for many years Italy and Germany dominated the manufacture of strings for musical instruments, while Eng-

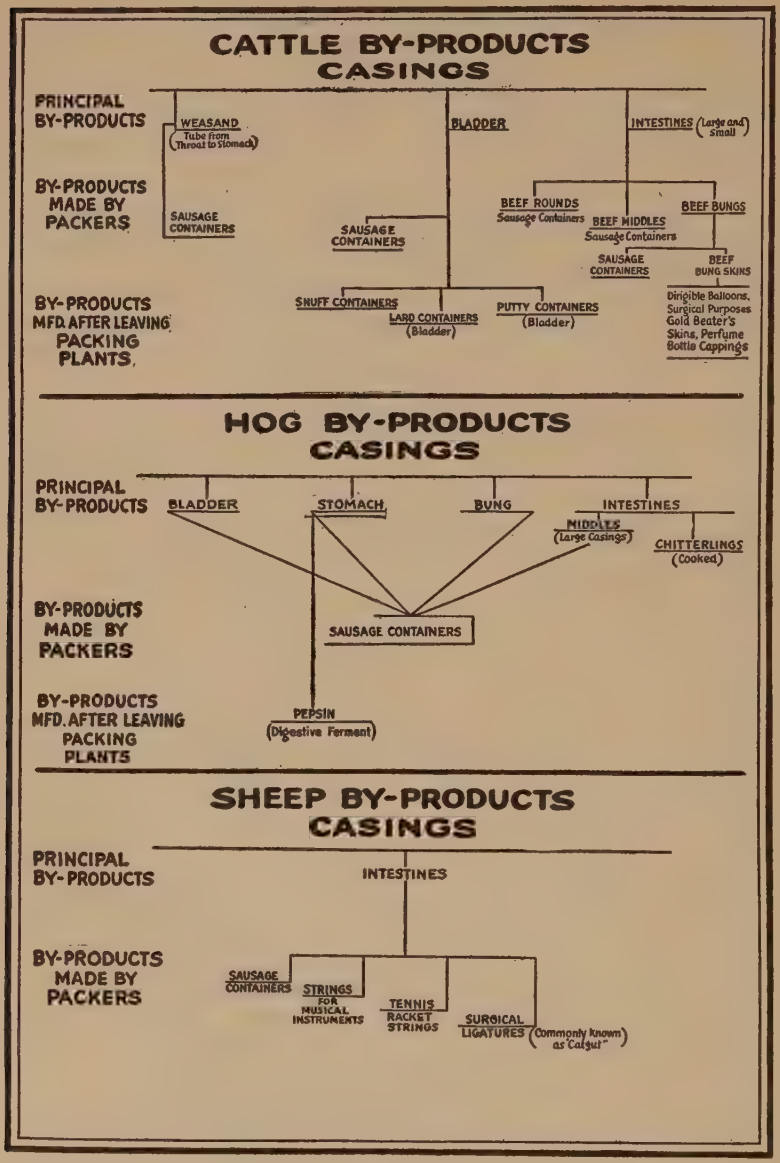

CATTLE BY-PRODUCTS
CASINGS
PRINCIPAL BY-PRODUCTS
WEASAND (Tube from Throat to Stomach)
BLADDER
INTESTINES (Large and Small)
BY-PRODUCTS MADE BY PACKERS
SAUSAGE CONTAINERS
SAUSAGE CONTAINERS
BEEF ROUNDS Sausage Containers
BEEF MIDDLES Sausage Containers
BEEF BUNGS
SAUSAGE CONTAINERS
BEEF BUNG SKINS
BY-PRODUCTS MFD. AFTER LEAVING PACKING PLANTS.
SNUFF CONTAINERS
LARD CONTAINERS (Bladder)
PUTTY CONTAINERS (Bladder)
Dirigible Balloons, Surgical Purposes Gold Beater's Skins, Perfume Bottle Cappings
HOG BY-PRODUCTS
CASINGS
PRINCIPAL BY-PRODUCTS
BLADDER
STOMACH
BUNG
INTESTINES
MIDDLES (Large Casings)
CHITTERLINGS (Cooked)
BY-PRODUCTS MADE BY PACKERS
SAUSAGE CONTAINERS
BY-PRODUCTS MFD. AFTER LEAVING PACKING PLANTS
PEPSIN (Digestive Ferment)
SHEEP BY-PRODUCTS
CASINGS
PRINCIPAL BY-PRODUCTS
INTESTINES
BY-PRODUCTS MADE BY PACKERS
SAUSAGE CONTAINERS
STRINGS FOR MUSICAL INSTRUMENTS
TENNIS RACKET STRINGS
SURGICAL LIGATURES (Commonly known as "Catgut")

FIG. 43

PACKING MUSIC AND TENNIS STRINGS

MUSIC AND TENNIS STRINGS BEING FINISHED

land led in the manufacture of strings for tennis rackets. Some twenty years ago American manufacturers began to experiment with intestinal material, which was being exported to Italy and Germany in its raw state, and imported as finished products from these countries. Certain tests among the products of the first gut-string manufacturers in America indicated that the finest materials were being produced in the United States, and that strings were of better quality if they were made from sheep intestines while they were in the best condition. This infant industry grew normally until, in 1914, the war hastened its growth in remarkable fashion, and American manufacturers were soon supplying the world-demand. Without the unfailing supply of this by-product from meat-packing plants, the violin industry, as well as the manufacture of cellos, harps, guitars, banjos, mandolins, ukeleles, etc., would have been compelled to cease operations during the great war, which stopped importations of foreign strings.

Music strings.—The music-string industry in the United States became so important during the war, due to the expanding operations of meat packers and the increased slaughter of American sheep, that the manufacture of violins actually increased 100 per cent. The manufacture of other musical instruments, including all of the stringed variety, also increased, but the violin led them all. New factories for the manufacture of stringed instruments were established in New York, Virginia, Ohio, Indiana, Illinois, and one or two cities in the South. The output of all musical-instrument factories was largely increased. The larger packers themselves went into the business of manufacturing strings for violins and similar instruments some fifteen to twenty years ago.

Italy and Germany continued to export large amounts of music strings to the United States until the World War. Italian strings were said to be the best, and were manufactured from the intestines of German sheep. However, German strings, which were regarded in some circles as second-best, were manufactured from intestines of Russian sheep for the most part. To determine whether American or foreign strings are the better, an experiment was made recently. A violin string made by an American firm was

placed in an envelope bearing the card of a foreign manufacturer. The foreign-made string was placed in an envelope of the American manufacturer. The expert selected the American string from the foreign envelope as the better article, and wrote a recommendation to that effect, which is prized very highly by the American manufacturer.

The American music string is smoother and more uniform in quality. Packers in America employ skilled workers and have improved on the original process, while manufacturers of foreign strings seem to have lost their skill during the war. It will probably be a long time before the supply of raw material in Europe is again available for the manufacture of music strings. Among the products sold by the music-string departments of large packing companies are the following: harp strings; guitar strings; music stands and cases; banjo accessories, including bolts, wrench, bridge, bracket, tail piece, patent heads; drum snares; guitar and mandolin accessories; violin bows and accessories; clock cords; and gut cables, the latter being used for a variety of purposes, such as billograph machines and typewriters, for which there is a growing demand.

Tennis strings.—In order to produce a sufficient quantity of strings for the racket of a tennis player, the intestines of eleven lambs are necessary. For it is only the intestines from strong, healthy, and vigorous lambs which can be strung into gut strings having resilience enough to stand up against the stiff volleying and smashing service that characterize the tennis player of today. In large packing plants, where the manufacture of gut strings is carried on systematically, the raw material goes immediately from the killing department to the gut-string department, where only 24 feet of the small intestines are used in the manufacture of gut strings. Strings are first split on a specially designed contrivance which resembles a wooden finger-shaped instrument in the center of which there is a sharp blade, set vertically. The splitting process has divided the strings into two grades, one of which is rough side, and the other smooth side, and these split strands are then treated chemically. The smooth side makes a

more uniform and durable grade of strings. Though only a second grade is made from the rough-side material, this quality is also quite satisfactory for use in musical and tennis strings.

Numerous operations follow, consisting mainly of chemical bathing and washing, before the strings are spun into shape and stretched upon drying frames. When spun, the strings range from 2 to 30 feet in length. No string less than 11 feet can be used successfully in stringing a tennis racket, and therefore the shorter lengths are used for musical and surgical strings. After the sorting, the strings are fastened together in various numbers ranging from one to two hundred ply, according to the size of the string which is to be made. In making tennis racket strings, twenty-eight ply of the smooth split gut is the standard, while eleven ply of the whole gut is used. The method and number of spinnings depend upon the kind of gut string that is being manufactured. The spinning of each string requires the art of two skilled, careful men who know exactly how many turns the old-fashioned spinning wheel must make.

After spinning, the strings are again treated chemically by being put through special baths. These processes preserve the natural color of the gut and have the effect of toughening the string. Following these two baths, the strings are put on frames in the drying-room and left until they are thoroughly dry and seasoned, a process taking from three to fifteen days. During this period of drying the strings are respun occasionally, especially when any lack of cohesion is noticed in them.

At this stage, strings are rough and unfinished looking, and are given to skilled workers, who stretch them on a machine, which keeps them turning, while the men go back and forth from one end to the other, polishing them until they are smooth and glistening. The time consumed in polishing is usually about 10 minutes. Some of the finished strings are darker than others, but this is due to inherent qualities of the sheep, and makes no difference in the resiliency or utility of the strings for tennis rackets. After the polishing comes the testing by special machines. Each tennis string must stand a test of 100 pounds before it shows

signs of breaking, and in that test it must show a stretching ability which will insure a racket with "snap" and "vim" to it.

Other Uses of Intestines

Intestines are used for a number of curious purposes which would not occur to one unless he were a student of the packing industry. For example, gold beaters use animal intestines as an aid in reducing the thickness of sheets of gold already beaten to a film. When thus placed between sheets of this parchment-like substance, as it becomes when dried and prepared, gold beaters can reduce the gold to an almost infinitesimal thickness. Again, some of the finer grades of intestines are used as caps for perfumery bottles, after the product has been cured and dried.

The edibility of the stomach of animals in the form of tripe is well known. The bladder is dried and sold to druggists and snuff-makers, while brewers utilize certain of the intestines which are specially prepared for them. The brewers use one intestine, about 7 or 8 centimeters in diameter and 40 in length, to line pipes in order to prevent the beer's contact with the metal. The intestines are glued end to end until sufficient length is assured for the desired purpose. A minor use is that of the membranes of the large intestine of the ox, which is used by surgeons in closing wounds and in making plasters.

There is, however, a very important medical use for intestines yet to be considered. This is the manufacture of surgical ligatures, which have been a great benefit to mankind. The surgical ligatures now made from sheep intestines were one of the valued articles in the hospitals of France during the war. In modern practice the delicate gut ligatures made from the strong silky side of the narrow sheep intestine, are employed by the surgeon, and this thread is taken up or absorbed by the flesh of the patient as he recovers, so that by the time he is well the stitches have disappeared. These ligatures have been perfected after much experimentation with animals. The first ones were made in such a way that they were absorbed too soon, because they were not

hard enough and the blood absorbed them quickly. After further research, processes were devised whereby these ligatures are now timed for ten, twenty, or thirty days. They are sterilized and kept in glass tubes, and the surgeon uses that particular grade of ligature that will dissolve in the wound at the end of a desired period of time. The social value of such products, while bringing financial profit to the packing industry, can never be adequately expressed in terms of money.

CHAPTER X

GLUE, GELATIN, AND RELATED PRODUCTS

Glue and gelatin are packing-house by-products which have developed such diverse uses that they have led the packing industry into many apparently unallied fields. For example, with the glue and gelatin works of national packing companies are intimately connected sandpaper, and anhydrous ammonia manufacture. Therefore all by-products of this type will be discussed in this chapter.

There are few articles that contribute to man's comfort and welfare that do not require glue at some stage in their production. It has been said that glue holds the world together. The manufacture of glue is a very old industry, for it is clear that the cabinet-makers of Egypt used glue 3,000 years ago, and it has been in common use ever since that time. However, until very recently the glue manufacturer simply boiled such stock as he had and dried the resulting extract, considering whatever he obtained as glue. But this old method has been changed by the application of chemical control, which makes possible the manufacture of select glues of different properties or value. The extent of this glue business today is summarized as follows:

PRODUCTION OF ANIMAL GLUE IN THE UNITED STATES, 1926

	Pounds
All glue*.	104,000,000
Hide glue....	62,000,000
Bone glue..	42,000,000

* Number of plants, 48.

This shows that hide glue represents 60 per cent, and bone glue 40 per cent, of the total production. Some thirteen manufacturers produce 92,000,000 lb. of glue. At an average price of 15 cents per pound, the value of glue produced yearly is over $15,000,000.

Glue and gelatin are chemically and physically much alike. They differ in that gelatin is a much superior product, since it is made from a selection of clean, sweet materials prepared under careful sanitary conditions in order to produce an edible commodity. High-grade glues are technically gelatins, but, since they are inedible, need not be made from such closely selected stock. Chemically, both glue and gelatin are colloidal proteins, and physically they lack a definite crystalline structure.[1]

The raw materials from which glue and gelatin are made, in the order of glue-making value, are as follows: skin or hide, connective tissue, and cartilage and bone of cattle and calves. Muscle tissue is of no value, and horns and hoofs, contrary to popular belief, contain no gelatin. Some of the glue-yielding materials, e.g., hide trimmings, connective tissue, etc., are removed at tanneries, but the greatest volume of stock originates at the packing-houses, and includes sinews, horn piths, pizzles, mammary glands, lips, ear tubes, and cattle, calf and sheep heads, knuckles, feet, and bones. These animal products contain the mother substance of glue, collagen, a product like glue in chemical composition, but insoluble in water at ordinary temperatures. However, in boiling water collagen breaks down to form glue or gelatin.

Skin or hide scraps from all animals are used as glue stock. The scrap from tanners is often sorted into classes to get more uniform treatment by the glue-maker. Fleshings and trimmings, splits, etc., yield glues similar to those from hide stock, but of lower grade. Raw hide scraps, lace leather, worn-out hide pinions, "loom pickers," and other used leathers are handled like fresh scrap. Sinews and tendons trimmed off by butchers require slower treatment than hide stock, but yield good grades of glue. With sinews or bone, cartilaginous material may be handled. Bones from various parts of the body differ somewhat in composition with reference to glue manufacture, due to (1) condition of the animals resulting from climate, region, feeding, age, and handling; (2) con-

[1] A comprehensive survey of glue and gelatin is to be found in Robert H. Bogue, *Properties and Constitution of Glues and Gelatins* (New York: McGraw-Hill, 1920), a work which has been found of material technical assistance to the present writer.

dition and treatment of the stock in preparation for market; and (3) the handling of the glue stock in the factory. This bone stock is usually divided into the following classes: (1) Green bone. This is brought fresh from the killing floors. (2) Packers' bone. This has probably had a preliminary cooking, removing a certain amount of the grease and glue; but it still provides a valuable glue stock and is usually sold in the dry condition. (3) Dry bone. This term is applied to bones that have been dried before shipment to the glue manufacturer, and junk bones of every sort picked up from any available source. This dry bone contains 25 per cent organic matter and 75 per cent mineral matter, mostly calcium phosphate.

Much of the fresh glue stock obtained from packing-house operations is preserved in some manner, usually by adding dry salt, which is an excellent preservative. This is removed by washing before the glue stock is put through the liming process.

The approximate moisture content, together with the yields of some of the most important glue stocks, are given in Table XXIII.

TABLE XXIII

Glue Stock	Moisture (Percentage)	Glue (Percentage)	Grease (Percentage)	Tankage (Percentage)
Ossein (protein from bones)	10	70–80	.....	5
Green salted calf stock	30–40	16	2	9
Green salted hide stock	30–40	18	3	10
Hide stock, dry	10	35	1	5–10
Hide split, green limed	50–70	14	.....	5
Green limed sheep skin	60	7	7	5–10
Coney stock (rabbit skin)	10	50–55	.....	20–25
Fleshings, green limed	50–70	8–12	5–12	5–10
Fleshings, dry	15	20–25	5–25	10–20
Sinews, salted	35–50	22–24	2–3	7–8
Green bones	40–60	10–12	5–20	25–45
Dry bones	10	18–20	1	60–70
Horn piths, dry	10–12	23	.....	65

The glue-maker requires also certain secondary raw materials. The chief one is water in large quantities, reasonably pure and free from mineral salts. The most important chemical is lime in the form of quick lime with high calcium content, slaked at time of using. Other materials are hydrochloric, sulphuric, and sulphur-

GLUE FACTORY—GLUE LIQUOR IN VATS

GLUE STOCK—HIDE TRIMMINGS, ETC.

ous acids, and various chemicals for special treatments, clarification, etc.

There are many kinds of glue, but those under the following heads are the most important as by-products of the packing business, viz., hide glue, bone glue, and blood albumen glue. The manufacture of each type will be described in turn.

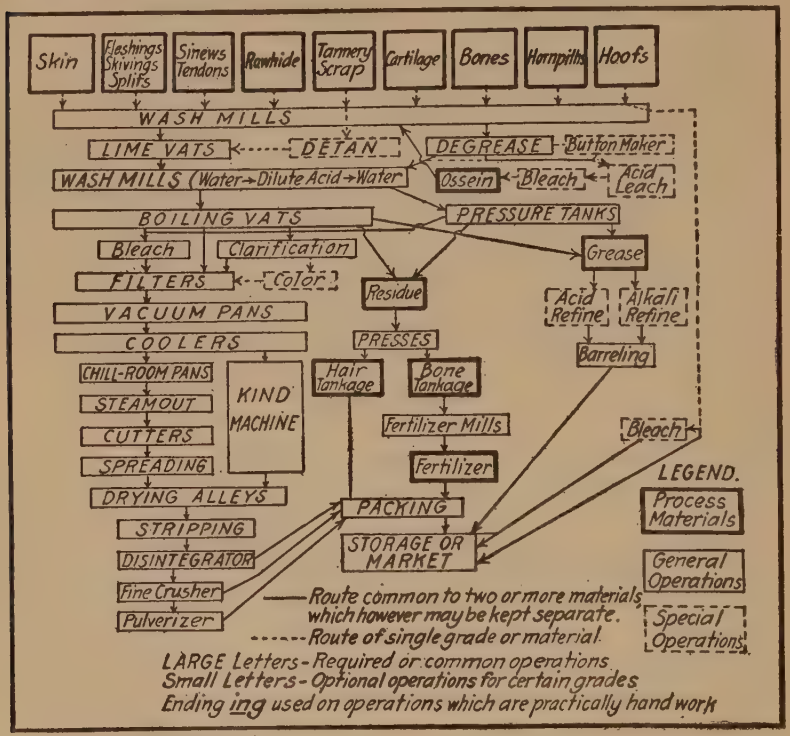
Hide Glue Manufacture

All glue stock must first be thoroughly soaked and washed to remove all salt, lime, blood, and dirt. This operation is performed in machines similar in principle to an ordinary family washing machine. Of these there are four representative types, any one of which may be used. The cone mill, which combines rubbing, kneading, and washing, is used on any kind of hide stock. In the tumbler, or barrel mill, which is more suitable for hard or thick stock, pounding or kneading is the main feature. The hollander mill utilizes the rubbing operation, which is most useful in loosening foreign substances, but cannot be used on heavy non-uniform stock. The half-round mill uses simple agitation and rapid circulation of water, and is excellent for finely divided or light stock.

The next process is liming, which consists of soaking the hide stock for 30–90 days in wooden or concrete vats with a milk of lime solution containing about 10 per cent of the weight of the stock, during which period the stocks swell considerably, due to the absorption of water. By this process the contaminating materials, albumens, mucin, and sometimes mucus, also some of the fats, are attacked by alkali, which renders them more soluble, so that they can later be removed by washing.

The liming process leaves the stock thoroughly plump and tender, but without a slimy surface. The stock is returned to the wash mills, where the excess of lime is removed, and is washed with dilute sulphurous or hydrochloric acid. The former is a bleach and an antiseptic and neutralizing agent, while both further increase the swelling of the stock and remove all remaining salts. After another washing in water, the stock is ready for the boiling tank.

The reason for boiling out the glue in successive stages or boilings is to prevent deterioration of the glue already extracted, due to hydrolysis or decomposition, into low-strength glue, or gelatin, caused by prolonged heating. The boilings of prepared hide stock and the open boilings of bone are practically identical. The term



Courtesy of McGraw-Hill Book Co.

FIG. 44.—Course of glue stock through the plant

"boiling" does not necessarily mean actual bubbling, but rather a gentle cooking at any desired temperature. This boiling is done in vats 6–8 feet in diameter and somewhat less in depth. Closed steam coils are placed under a perforated false bottom covered with a layer of excelsior or some other coarse filtering agent. The stock is immersed in warm or hot water, the steam is turned on, and the temperature kept at about 140° F. The cooking is carried on at this low temperature at first, but under the stress of heat the

GENERAL VIEW IN FERTILIZER FACTORY

collagen breaks down into glue. Cooking is continued from three to five hours at a comparatively low temperature. At the end of this time the heating is stopped, and the glue liquor is drawn off and fresh hot water added to the glue stock. Cooking proceeds again in the same manner, but at a slightly higher temperature than the first cooking. This is repeated four, five, or six times, until all the collagen is removed and converted into glue. The last cooking is made at the boiling point of water.

Glue liquors thus obtained are often clear enough, but if a very brilliant glue is wanted the liquor must be filtered to clarify it. To remove the coarser particles the glue is forced through cloth in an ordinary press. For finer filtering the liquor is drawn through a pulp filter mass by gravitation or by pressure. However, a further step is often taken to remove any precipitate which may be clouding the glue liquor. If albumen is added to a cool liquor the temperature of which is gradually raised until coagulation takes place, a clear liquor ready for filtering and evaporation will result. This evaporation is usually done in vacuum pans, because lower boiling temperatures are obtained under vacuum than at atmospheric pressure. In this way the glue or gelatin is not subjected to long heating at high temperature, which would deteriorate the product. For the production of glues with special properties, other substances are sometimes added, e.g., glycerin, sugar, or tar oil, which impart greater flexibility; or calcium chloride, sodium naphthalene sulphonate, acids, or chloral hydrate, which prevent jellying and produce a liquid glue.

Chilling and spreading, the next operation, is performed in various ways. One method is to run the liquor into pans 8 or 10 inches wide, about the same depth, and 2 or 3 feet long. These pans are placed in cold running water or in a refrigerator until the liquor congeals, after which the block of jelly is removed by dipping the pan in warm water, or inverting it and passing it through a steam box. The block is then either cut into slices, by being fed endwise to a spiral rotating knife, or is cut longitudinally into thin slices by being drawn along a traveling belt between uprights across which are stretched taut piano wires. In either case the re-

sulting slices of glue are spread by hand upon frames carrying nets usually made of galvanized iron wire, although copper and monel-metal nets are also used.

Recently the Kind & Landesmann spreading machine has come into somewhat popular use. In this machine the evaporated liquor runs upon a traveling rubber belt which passes through a refrigerating chamber, traveling at such a rate and for such a distance that by the time it again emerges the liquor has congealed into a thin continuous sheet. This is stripped from the belt automatically by means of the moving frame, and falls upon this frame, which is traveling at the same rate as the belt. It is evident that, with this machine, comparatively very little labor is required; nor is there any scrap to be returned for remelting, as in the old processes.

In either case the frames are stacked on trucks and run into drying alleys where warm, dry air completes the evaporation and produces the commercial sheet glue. The final drying is accomplished in long tunnels or alleys which receive the trucks, each of which is stacked with some twenty frames of glue. These trucks are guided through the alley by tracks and the glue is completely dried by a current of air forced against it. On being taken out of the alleys, the sheet glue is stripped from the nets by hand, and is then broken up by means of crushers, thus producing the flake glue of commerce, or is ground into coarse or fine powders.

Bone Glue Manufacture

As processing bone stock is much like that of hide stock, it will be described but briefly here. Green bone is crushed and washed in water and in dilute sulphurous acid, after which it is degreased before storage by a short preliminary boiling. It is then spread out and dried, yielding a product similar to commercial "packer bone." To put bone into the best possible condition for glue making, practically all of the grease can be removed by solvent extraction through the use of benzine, after which the bone is dried and made ready for the manufacture of glue of good grade and color.

Following such treatment, shin bones are dried and sold as

fancy bones for button and novelty making. Hoofs and horns, being of no value to the glue-maker, are generally cut to certain shapes, steamed and molded in a press while hot, or are ground into a powder and made into a mixture which can be molded like any other plastic. Less desirable horns and hoofs are often ground and mixed into fertilizer.

Green bone may be boiled, with no preliminary treatment other than a thorough washing and a charge or two of weak acid. If boiled in open tanks like hide stock, the time of boiling is increased to about twenty-four hours per run, the temperatures used are higher, and some five or six runs are made. If autoclaves or pressure tanks are used for boiling, the time is materially shortened because of the higher temperature obtained; the liquor is more easily clarified; and the bone residue is softer and more completely extracted.

The liquors from bones are treated similarly to hide glues throughout the remainder of the process, with the exception that, as they are of a lower test, they are evaporated to a higher concentration before being chilled and cut.

Bone, exclusive of the marrow, blood vessels, nerves, and the like, consists of a cell substance and matrix, which, as a source of glue, is known as "ossein." The cell substance is very resistant to both acids and alkalis, and yields no gelatin on boiling with water. The organic portions of the matrix yield gelatin, and the problem of the manufacturer is to prepare the bone in such a manner that the transformation into gelatin may be conducted with the least possible deterioration of the product.

Prolonged treatment with dilute acid seems to be the most efficient method of preparation; but, at the same time, it is the most troublesome and expensive. By such treatment almost all the inorganic substances are removed. The cell substance is partly lost, the little which remains being the truly insoluble portion, and there is left only the periosteum and the organic portion of the matrix. This ossein can be limed and handled in a manner similar to hide and sinew stock. A bright strong gelatin of the highest quality is obtained, if the proper care is used throughout the proc-

cess. For the making of ossein, selected degreased stock only is used, horn piths, dentelles, jaw bones, knuckles, and ribs being among the most desirable. The number of acids suitable for the production of ossein is rather limited.

Blood Albumen Glue

The manufacture of blood albumen glue on a commercial scale was due to the sudden war demand in 1918 for a water resistant adhesive in making ply wood for military purposes. Following an intensive study of all possible sources of waterproof glues, blood albumen glue was found to be the most satisfactory product. This glue may be prepared from fresh blood or dried albumen. If the former is used, the supply must be readily accessible to the consuming plant, for decomposition quickly unfits it for glue purposes. If the latter is used, the ground albumen is dissolved in water at a temperature of 70°–80° F., following the addition of ammonium hydroxide and lime, and the solution is agitated and strained in order to get a uniform consistency.

Blood albumen glue is used almost entirely in manufacturing ply wood. It is spread by machinery to insure evenness, and a high temperature in the press is imperative for its proper setting. The high temperature brings about the coagulation of the albumen, and it is this insoluble coagulum which renders the product resistant to the action of hot or cold water. An interesting property of this glue is developed in very thin veneering. When thin plies from 1/30 to 1/125 of an inch in thickness are treated with ordinary glue it usually penetrates through the face plies, and curling, wrinkling, and overlapping occur, due to the excessive or uneven swelling of the thin veneer from rapid absorption of water. The water-resistant properties of blood albumen glue completely overcome this difficulty.

Unfortunately there is no one satisfactory test for glue, but glue manufacturers are experimenting on new and simple tests. At the present time a number of chemical and physical determinations are used, which include jelly strength, viscosity, acid reaction, grease content, and absence of foaming properties.

Uses and Applications of Glue

The oldest important use to which glue was put was the joining together of two pieces of wood. The ancient craft of cabinet-making still uses a great deal of glue, and the veneer industry is one of the largest glue consumers. Panel work is a highly specialized craft which yields artistic effects, conserves the more valuable timbers, and produces greater strength with less weight. The strength in a glued joint varies with the following factors: the kind of glue; the concentration of the glue solution; the time occupied and temperature employed in heating the glue; the temperature of the glue when applied; the species, density, porosity, and moisture content of the wood used; the trueness of the joint; the amount and method of application of the glue in the joint; the temperature of the wood when the glue is applied; the rapidity of handling; the pressure applied to the joint, and the uniformity of its distribution; the time under pressure; the time of curing; the temperature and humidity during curing; the method of breaking the joint; and the hydrogen-ion concentration of the solution.

Glue is used in the sizing of paper, and thereby serves two distinct purposes in the manufacture of wall paper: (1) as a binder for the clay, Paris white, or other material with which papers are grounded, and (2) as a sizing agent for the ground colors and, in some cases, for the top colors.

In ordinary sized paper the glue is applied as follows: It is either put into the beater with the paper pulp previous to making, or the paper is run through a dilute bath of glue just before drying. The latter process is the more economical. In sized paper nothing is used with the glue except a little alum to increase the body and give the paper a somewhat harder finish. Coated paper is made by applying a texture of glue and pigments, or fillers of almost the consistency of cream after the paper has been finished.

Both glue and gelatin are used widely in manufacturing wool, silk, and other fabrics, either as a size to be mixed with dye, or as a finishing size for the whole fabric. In textile manufacture purity of the glue is vital. Black silks are often treated with a mixture of oil acid, soda, and glue as a finishing process to dispel the fuzziness

resulting from the drying process. Glue is used on cotton goods and on cotton batting to stiffen the material. Carpets, tapestries, burlap wall coverings, curtains, etc., are all heavily sized with glues where stiffness is desired. All straws for hats are heavily sized, and certain hardening agents are used to make them water resisting.

Barrels and casks for liquids are sized before use, for otherwise the liquid would penetrate the wood and be lost, or would aid in decaying the wood. A few quarts of the glue in solution are introduced into each barrel, and steam is applied under low pressure to force the solution well into the pores of the wood. The barrels are rotated and finally drained while still hot. A large amount of the glue is diverted to the painters' trade to size walls before painting, to fill pores, etc. In this work a cheap low grade of glue is used.

Glue is used in match manufacture as a binder and to form a strong film about the head of the match, to exclude air and thus prevent possible ignition of phosphorus, which is easily oxidized in the air. For this purpose there is needed a moderately strong and rather viscous glue.

Sandpapers and emery papers require large amounts of a fine grade of hide glue, possessing extreme viscosity and at the same time a strong jelly strength. In making sandpaper, the paper is passed between rollers which supply a rather concentrated solution of the glue to the upper surface, and the sand or emery, which includes garnet, carborundum, and alundum of the selected size and grain is sprinkled thickly over it. Following this, the excess of sand is shaken off and the paper is passed slowly along. In about a half-hour it reaches a second set of rollers, where it is treated again with a layer of the same glue, but of weaker concentration, which binds the sand so firmly that it cannot be easily loosened. Finally, the paper is passed slowly over heated pipes for about an hour and then wound into rolls, or cut to appropriate sizes and baled.

Some individual national packers maintain a daily production equal to a sheet of sandpaper 24 inches wide with a total length of about 20 miles. To a limited extent glue acts as a binder for

RUNNING GLUE ONTO WIRE FRAMES

MAKING SANDPAPER

abrasive wheels, for which purpose only the highest grades are suitable. Molding material is made from a mixture of blanc lead carbonate (white lead), calcium sulphate, sawdust, and glue, and is used extensively in making moldings for picture frames, mirror frames, rosettes, etc. Other plastic substances such as dolls, toys, ornaments, etc., are made of materials in which glue is an important constituent. Billiard balls are made by dissolving ninety parts of glue in a minimum of water and adding five parts of barium sulphate, four parts of calcium carbonate, and one part of linseed oil. A small ball is formed and allowed to dry. Then it is made larger by adding another layer, and again drying. This process is repeated until the ball is of standard size, after which it is allowed to dry for three months and then turned on a lathe to make a perfect sphere. The finished ball is immersed in a solution of aluminum sulphate for an hour, dried, and polished. Other uses of glue include composition cork, which employs glue or gelatin as the binder. An imitation of hard rubber is made by mixing a thick solution of glue with a solution of sodium tungstate in hydrochloric acid.

Printing rollers are manufactured from a combination of best hide glues with glycerin, or some other substance, which is added to give the product elasticity and springiness. Hectograph plates are produced by making glue, or a gelatin-water-glycerin mixture, adhere to oiled paper or cloth. Only high-grade glue or gelatin can be used for hectograph plates. An artificial silk has been prepared from a very high grade glue or gelatin treated with potassium bichromate to render the product insoluble, pliable, and firm. The solution is forced through fine holes by a strong pressure, and the resulting threads, after being dried in the sun, are dyed and woven into cloth. Water makes the product limp, but it becomes firm again upon drying.

Gelatin veneers are preparations of glue with earthy material, by which imitations of marble, mother of pearl, lapis lazuli, malachite, ivory, tortoise shell, travertine, etc., may be made by a proper coating of a board, stone, piece of glass or crockery with the "veneer" desired. For imitating marbles and enamels, a high-grade glue solution containing finely ground zinc oxide is poured

upon a prepared horizontal surface, a design is traced with a glass rod, and glue solutions colored by the appropriate dyes are poured on the surface to conform with the design. To make mother of pearl, a small amount of silver bronze is mixed with the clear glue solution, and traces of anilin colors, especially those producing fluorescent colorations, are added to different portions of the glue. Portions are poured successively into a prepared glass plate and the pattern is produced by deft manipulations of a comb or other instrument.

A high grade of glue or gelatin has often been found of great value in electro-metallurgic processes for the production of smooth hard deposits in electrolysis. In rubber manufacture, glue is also finding extensive application. It is capable of replacing the rubber to the extent of 10–20 per cent without any very appreciable loss in the desirable qualities of the product. In acid pickle baths, which are employed for cleaning and removing stain from iron and steel, especially just prior to galvanizing, glue is of value. Finally, India ink consists of very finely divided carbon suspended in water containing a little glue or gelatin, or some other colloidal material. The pure, finely divided lampblack is made into a thick paste, with a dilute solution of the glue containing a little musk or ambergris, and it is then molded and dried.

Summarizing the uses of glue produced by meat packers, the most important industries providing a market for glue are: (1) The wood-working industry, which consumes about 25–30 per cent of the total production, of which amount the furniture business takes about 15 per cent. (2) The manufacture of paper, gummed tape, and paper boxes, totaling 12–20 per cent. (3) The kalsomine industry, which requires 5–15 per cent. (4) The manufacture of sandpaper and matches uses 5 per cent of the glue produced. From about one-half of 1 per cent up to 5 per cent of the glue production goes into each of the following industries: automobile body, casket, cooperage, bookbinding, rubber, and emery wheels.

There appears to be a favorable outlook for animal glue in the following industries; coating of paper, sizing of paper, gummed

tape, kalsomine, chemical industries, and bookbinding. There will probably be no material change in the amount of glue sold for joint work in furniture, veneer, millwork, sandpaper, matches, and leather goods. A decrease in the use of animal glue is probable in the manufacture of automobile bodies, caskets, cooperage, leather belts, and straw hats. There is no decided trend regarding uses of glue in textile sizing, shoes, shade cloth, print rollers, reed furniture, and rubber products. Possible future uses of glue in any industry depend upon a number of factors, among which the following are important: (1) Changes in the size of the industry using glue. For example, if it increases, the consumption of glue will be greater. (2) Changes of a technical character. For example, the manufacture of steel automobile bodies decreased the use of glue in the automobile business. (3) The use of substitutes.

Gelatin Manufacture

While gelatin is not commonly manufactured in meat-packing plants, its raw materials originate in the packing-house. The manufacture of edible gelatin differs from the making of glue much as the manufacture of edible pure lard differs from that of grease. The methods are practically identical, except that in the case of gelatin more care must be taken in selecting the raw materials, and extreme cleanliness is necessary in production, handling and processing.

Generally speaking, the white fibers of connective tissue, when boiled with water, first swell and then dissolve to form gelatin, a typical colloid. Chemically, the white fibers are known as collagen, which is very generally distributed in animal tissue. It is probably not a single chemical substance, but represents a group of closely related substances of slightly differing properties.

The raw materials for gelatin manufacture may be hide stock, green bone, or ossein, and all commercial gelatin is classified according to its source, viz., hide gelatin or bone gelatin. If hide stock is utilized it is preferably that of young animals. About 50 per cent of the gelatin produced in the United States is made from calf stock. If green bone is used, selected parts of the animals,

such as jaws, feet, and knuckles, are chosen from the packing plants and worked up at once to retain the freshness and delicacy. These processes must be watched carefully to prevent bacterial decomposition. Indeed, the whole plant must be so constructed that the equipment may always be kept neat and clean, an end attained in part by the use of aluminum for containers.

Hide gelatin is normally made from clean calfskins, pigskins, and trimmings from other hides and skins. The pieces of skin are first treated for a considerable period with milk of lime in liming vats. They are then thoroughly cleansed in a mechanical washer under running water, and are taken to the cooking kettles, in which several cookings are made. The first liquors are taken off at a low temperature: as low as 130° or 140° F. These produce the best and strongest gelatin. Successive runs are taken off at increasing temperatures until seven or eight cookings have been made. Some of the runs are combined, and all of the liquors are evaporated under a vacuum, avoiding any undue temperature or period of heating which would weaken the product by hydrolizing it.

The concentrated liquors are allowed to set to a jelly in pans in a chill room, or in sheets upon a rubber belt in a continuous chilling machine. The pan-chilled jelly is next sliced by hand and the sheets are spread upon wire nets in a drying tunnel, through which a strong blast of dust-free air, carefully regulated as to temperature and humidity, is blown. The machine-chilled sheets are spread in the same manner and dried to a moisture content of 8 or 9 per cent for convenience in crushing and grinding. Upon storage, the moisture content usually rises to 11 or 12 per cent under ordinary atmospheric conditions. Gelatin is sometimes dried upon the surface of a drying roll or wheel.

A great development in the manufacture of gelatin has recently been made. In this newer process the clarified liquor, as it comes from the filter, is run onto a large heated metal wheel, where a thin layer is immediately dried and cut off on the other side. The wheel is about twenty feet in diameter. The liquor is fed onto this wheel from the filters in a constant stream, and with-

in thirty seconds a dry sheet of gelatin is removed on the other side. These sheets are then broken up or ground. The time-consuming operations of chilling and drying in the alleys or tunnels are thus avoided, a purer product is secured, and the expense of air washing and filtering is eliminated. In this process very few bacteria can contaminate the gelatin, and the quick drying allows no opportunity for these to develop.

Bone gelatin is made from the clean bones derived from the heads and feet of cattle, sheep, and hogs. These are first boiled to remove the fat, which is skimmed from the cooking vats. After the bones are crushed, gelatin may be obtained from them by boiling in an open vat (poor yields) or by cooking in steam pressure tanks (better yields); but the usual procedure is first to separate the ossein from the bones.

Uses and Applications of Gelatin

Most of the uses of gelatin are the direct result of chemical research, but in early days it was limited to a very few trades. Today pure gelatin has both edible and commercial uses, e.g., as a food and as a protective colloid in dietetics, in photography, and in pharmaceutical products.

Gelatin has considerable dietary value, but it cannot supply more than about one-third to one-half of the required nitrogenous matter necessary to maintain a nitrogen balance in the body. However, it is as complete a protein as many of the vegetable proteins. In this sense the term "complete protein" means a protein which contains all of the amino-acids required for the nourishment of the human body. The addition of gelatin to cow's milk for infant feeding has beneficial features in preventing coagulation of the milk during digestion. The gelatin functions through keeping the fat in a finely divided condition.

Gelatin has been used for a long time in making ice cream, especially by manufacturers operating on a large commercial scale. About 250,000,000 gallons of ice cream are consumed annually in the United States, and a pound of gelatin is used to every 50 gallons of ice cream. The total amount of gelatin used annually in

this business, therefore, is about 5,000,000 pounds. The advantages of the use of gelatin in ice cream are due to three of its colloidal properties, viz., (1) its production of a jelly at low temperatures; (2) its "protective" nature, which prevents, or greatly diminishes, the tendency of other substances to crystallize out, or separate, from the mixture, and (3) its function as an emulsifying agent, so as to render more permanent the retention of the milk fat in its aqueous medium. Gelatin acts beneficially in ice cream in three ways: it improves the "body" of the product, it improves the texture, and it improves the stability or keeping qualities.

In the making of emulsion flavors for baking and confection trades, gelatin may be employed. Addition of a little gelatin to a thin cream will make it easy to whip, and solutions sold for that use often contain gelatin and some vegetable gum. In the manufacture of marshmallows and other confectionery foams, gelatin is employed, and gelatin and egg albumen have both found service in baking powders and prepared flours to give increased openness of texture. In making mayonnaise dressings, the white of eggs, or commercial egg albumen, has been used as the emulsifying agent, causing the olive, cottonseed, or corn oil to emulsify with water, vinegar, or lemon juice. In some instances gelatin is a satisfactory substitute. In the preparation of non-edible emulsions, such as are used for agriculture and industrial purposes, gelatin or a high-grade glue are also much in demand. Isinglass and gelatin are used in clarifying beer, wine, and vinegar.

Gelatin has uses in the making of certain pharmaceutical preparations. When over 0.1 per cent formaldehyde is added, it produces a jelly that may not again be melted, or brought into solution by heat or the addition of more water. This jelly differs from an ordinary gelatin gel in being rubbery and possessing less strength when cold. The dried and powdered product known as formogelatin is employed as a surgical dressing. Due to the antiseptic action of the formaldehyde, it remains sterile and is a germicide.

Capsules as containers of doses of medicine are used in very

large quantities. They are made from a pure food gelatin by dipping an iron rod in a strong solution of the latter containing a little glycerin or sugar. The end of this rod is shaped according to the capsules required, and is highly polished so that the gelatin when cool may be easily detached. The dipping and the cooling may be repeated until the desired thickness of the capsule is obtained. After being removed from the rod, capsules are thoroughly dried and are then ready for use.

For coating pills gelatin is also used. The object is not only to eliminate the taste of the pill in swallowing, but, depending upon the specific case, to prevent evaporation of inclosed moisture, to prevent crumbling, to prevent sticking together, or to prevent other undesirable changes taking place in the pill. Court plaster is made from a mixture of gelatin, alcohol, and glycerin.

Gelatin finds a highly important place in photography and photolithography. A large amount of highest grade gelatin goes into service as a coating upon the films, plates, and developing papers. This coating contains the silver salts and other constituents of the light-sensitive portion of the film. If the gelatin is not of purest quality, reactions will occur between it and the sensitive silver salts; or, in the later stages of the development and fixing of the picture, reactions resulting in stains and other defects may take place. The dried gelatin film must be made so that it will have the right degree of porosity to permit penetration of electrolytes, but to prevent escape of the precipitated silver. It is due to the protective action of the gelatin that the precipitated silver remains finely divided as an even, thin deposit. Other colloids, on account of their inferior protective action, are less adapted to this service and cannot advantageously be substituted for gelatin.

When a gelatin solution is treated with a soluble bichromate, allowed to settle, and exposed to the action of strong light, the gel becomes insoluble. This reaction has been applied with success to the process of photolithography. The treated gelatin is allowed to form a jelly on a glass plate, and is exposed through a photographic negative to a strong light. That portion of the gelatin plate which receives light through the negative will be rendered

insoluble, and later, when placed in water, will not swell to the same extent as the parts which were protected from the light by the deposit on the negative. Furthermore, the amount of swelling which any part of the plate will undergo is in exact inverse proportion to the amount of light which penetrates the negative. The picture is thus reproduced upon the gelatin plate. This plate may then be covered with graphite and copper deposited upon it in an electrolytic solution, in which case the resulting copper plate, backed with easily fusible metal poured upon it, may be inserted in a printing press. This process, in one form or another, has been in use for a great many years.

Finally, gelatin is also used as a bacteria culture medium, for making cells for ultra-filtration, for bringing about certain quantitative analytical determinations, and as the best medium for demonstrating a large variety of colloidal phenomena.

By-Products of Glue and Gelatin Manufacture

From the making of glue and gelatin there result a number of by-products whose commercial value is great enough to enable the glue and gelatin manufacturer, through their processing or sale, to reduce materially his production costs.

The most important by-product, in quantity, is the residue from boiling bones. When this residue is discharged from the boiling vat or pressure tank it is soft and easily crushed. It is then spread while steaming hot on gunny sacks in layers of about 6 inches in thickness, completely surrounded by the sack and stacked alternately with lattices made of wood in a hydraulic press. Here the last of the glue liquor and grease are pressed out and returned for further processing. The press cake is broken up and spread out to cool and dry, or it is placed in a rotary direct heat, or steam dryer. The cake is then analyzed and mixed with other constituents to form a fertilizer, and is ground and sacked for market. Hair tankage, the residue left from the boiling of hide stock, fleshings, etc., contains a great deal of lime soap, as well as hair and other organic matter. To recover the grease the tankage is boiled with dilute sulphuric acid and pressed in the same man-

ner as the bone tankage. The remaining hair may be used as such or treated with hydrofluoric and sulphuric acids and converted to ammonium sulphate for fertilizer.

Grease is an important by-product. From the hock joint of cattle neatsfoot oil is obtained; and, on account of its value, the hock joints are always boiled separately. The clear oil from sweet fresh bones gives a tallow of good color and test. Bone tallows have always a lower melting-point than the tallows obtained from other parts of the animal. The oil from pigs' feet has the lowest melting-point of any of the oils produced at the glue works, while that from sheep stock naturally has the highest, as mutton tallow has a high melting-point.

The grease from the later boilings contains considerable lime soap, as does also the press grease from the hair tankage. This is most easily decomposed by boiling with acid, after which it is washed with water to insure good keeping qualities.

Blood and Its Products

Unless treated at once, blood quickly clots into a jelly-like mass and separates into blood serum and a fibrous, insoluble substance containing a high percentage of nitrogen or ammonia. After clarification, the blood serum may be dried and sold as blood albumen. The fibrous portion is made into dried blood for stock feeds or fertilizer.

In large packing plants the blood from all animals slaughtered is usually collected, and, unless albumen is manufactured, it is pumped to a coagulating tank. This coagulating tank is usually a cylindrical cone-bottomed tank, fitted with an open steam line in the center bottom of the cone. When the tank is filled, open steam is turned in and the contents are cooked until they are coagulated and possess about the consistency of liver. After standing for a while, there will be a sharp separation between the coagulated blood and the water, which will settle at the bottom of the tank. This water is drawn off and pumped away to evaporators, where it may be concentrated with a resulting evaporation of some 70 per cent of its bulk.

The residue of the coagulated blood is placed in hydraulic presses, and more moisture is driven off by pressure. The pressed blood is then put into dryers. The solid cakes thus produced are then reduced by attrition to a fine powder, which can be disposed of as blood meal or mixed with potash or phosphoric acid, thus making a rich fertilizer. Ordinary blood contains about 17 per cent of ammonia, of which 14 per cent is pure nitrogen. Because blood decomposes very easily and rapidly after slaughter, and thereby liberates this nitrogen or ammonia, it is cooked at once.

The best grades of blood are used for the refining of sugar. When desired for this purpose, the blood is dried at a low temperature in order to prevent the coagulation of the albumen. The resulting cakes are dissolved in warm water and added to the liquid sugar. As increasing heat is applied, the albumen rises as a scum, carrying with it the impurities in the sugar. The syrup is then filtered through bone-black, another by-product of the packing plant made from calcined bones. The inferior grades of blood are employed in the manufacture of buttons, being pressed into shape by hydraulic machinery. Imitation tortoise-shell articles are also composed largely of blood. Defibrinated blood is now extensively used as a medicine, when the patient's blood lacks red corpuscles. A preparation containing iron for therapeutic use is also obtained from blood.

Dried blood is one of the most concentrated stock foods, as it contains about 87 per cent protein, and gives exceptionally good results when fed to horses and other livestock with their regular feed at the rate of two or three ounces a day. Scours and other forms of dysentery, which frequently trouble young calves, can be cured by the addition of a little dried blood to the milk on which they are fed. The blood of an average ox weighs about 40 lb., and the price of processed blood averages $35.00 to $45.00 per ton.

Blood albumen, which, up to recent years, had been imported entirely from Europe, is now prepared by packers, and is similar in appearance to the white of an egg. When its temperature is raised to a certain point it coagulates. This blood albumen is used by calico printers in fixing certain pigment colors in cloth. After

the cloths are printed they are steamed at a temperature approximating 200° F. This action coagulates the albumen in the ink, rendering it insoluble in water, and mechanically fixes the colors to the fabric. Albumen also is used by tanners in finishing leather, by malters of certain extracts, and for the clarifying of liquors. It is employed in plaster as an agent to prevent settling or hardening too quickly.

Handling of Bones, Horns, Hoofs

Bones, particularly cattle bones, are among the most widely used by-products of the packing plant. They are utilized in the manufacture of neatsfoot oil, which is very valuable for the treatment of leather and the lubrication of watches, gun carriages, and other articles. Neatsfoot oil is considered the best basis of leather dressings, because when worked it has the property of keeping the leather soft and pliable under all conditions of moisture and temperature. Bone oil is widely used in the manufacture of tankage, glue, and gelatin, while the steam bone residue forms a valuable part of fertilizer. The products of hard, or commercial, bones may be seen in almost every retail store throughout the country as buttons, knife handles, toilet-set handles, beads, ornaments, and hundreds of other articles. Hard bone is also ground up for use by manufacturers for case-hardening steel. It is also widely utilized in poultry feed.

Many packers do not find it advisable to handle the bones themselves, and after carefully trimming off all the meat possible, sell them in a "green" or raw state to commercial bone dealers, renderers, or glue manufacturers.

Packer bones are those killing- and cutting-room bones, e.g., skulls, jaws, blades, rumps, and knuckle ends sawed from commercial bones other than those used in case-hardening, which have been subjected to one or more cookings for the purpose of recovering high-grade glue water, as well as tallow. After this cooking, the bones are still in their original shape, and upon washing and drying, they are sold to glue or gelatin manufacturers, or for use in pressure-tank cooking in order to recover any tallow and glue left in them during earlier low-temperature open-vat cooking.

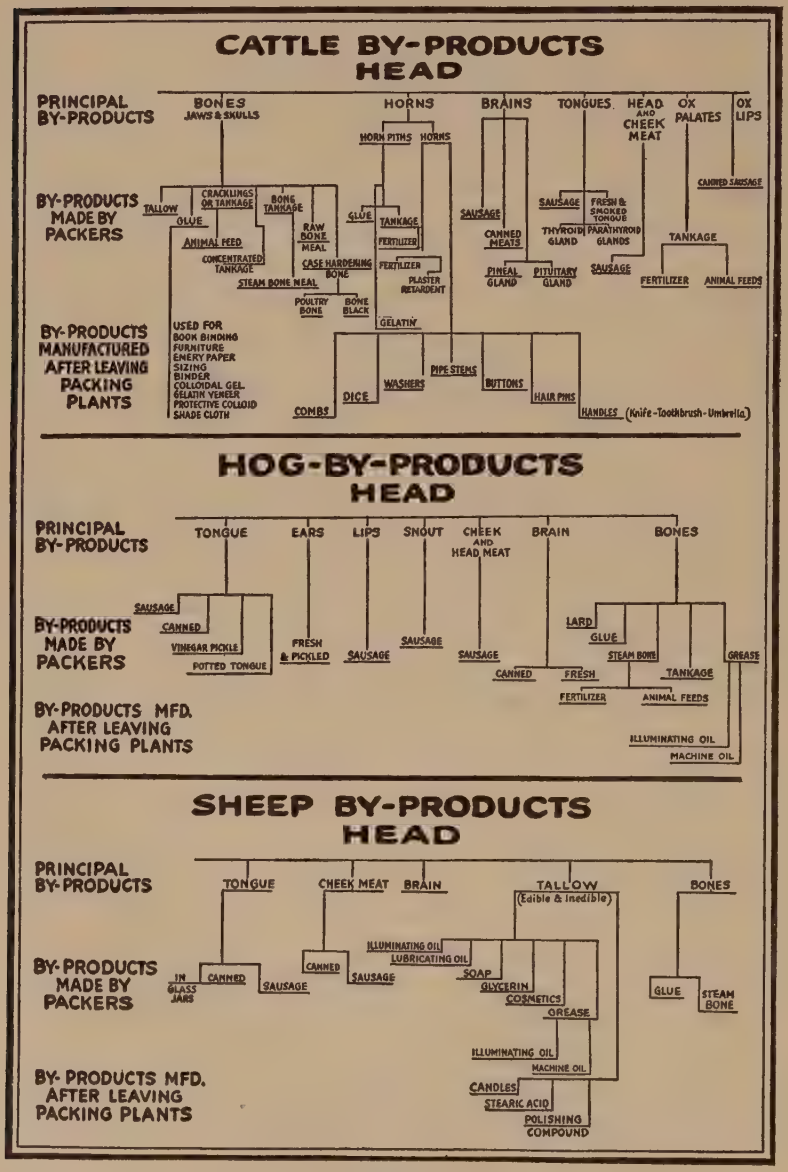

CATTLE BY-PRODUCTS
HEAD
PRINCIPAL BY-PRODUCTS
BONES
JAWS & SKULLS
HORNS
BRAINS
TONGUES
HEAD AND CHEEK MEAT
OX PALATES
OX LIPS
HORN PITHS
HORNS
CANNED SAUSAGE
BY-PRODUCTS MADE BY PACKERS
TALLOW
CRACKLINGS OR TANKAGE
BONE TANKAGE
OLEO
ANIMAL FEED
CONCENTRATED TANKAGE
STEAM BONE MEAL
RAW BONE MEAL
CASE HARDENING BONE
POULTRY BONE
BONE BLACK
GLUE
TANKAGE
FERTILIZER
FERTILIZER
PLASTER RETARDENT
GELATIN
SAUSAGE
CANNED MEATS
SAUSAGE
FRESH & SMOKED TONGUE
THYROID GLAND
PARATHYROID GLANDS
PINEAL GLAND
PITUITARY GLAND
SAUSAGE
TANKAGE
FERTILIZER
ANIMAL FEEDS
BY-PRODUCTS MANUFACTURED AFTER LEAVING PACKING PLANTS
USED FOR
BOOK BINDING
FURNITURE
EMERY PAPER
SIZING
BINDER
COLLODIAL GEL.
GELATIN VENEER
PROTECTIVE COLLOID
SHADE CLOTH
COMBS
DICE
WASHERS
PIPE STEMS
BUTTONS
HAIR PINS
HANDLES (Knife-Toothbrush-Umbrella)
HOG-BY-PRODUCTS
HEAD
PRINCIPAL BY-PRODUCTS
TONGUE
EARS
LIPS
SNOUT
CHEEK AND HEAD MEAT
BRAIN
BONES
BY-PRODUCTS MADE BY PACKERS
SAUSAGE
CANNED
VINEGAR PICKLE
POTTED TONGUE
FRESH & PICKLED
SAUSAGE
SAUSAGE
SAUSAGE
CANNED
FRESH
LARD
GLUE
STEAM BONE
GREASE
TANKAGE
FERTILIZER
ANIMAL FEEDS
BY-PRODUCTS MFD. AFTER LEAVING PACKING PLANTS
ILLUMINATING OIL
MACHINE OIL
SHEEP BY-PRODUCTS
HEAD
PRINCIPAL BY-PRODUCTS
TONGUE
CHEEK MEAT
BRAIN
TALLOW (Edible & Inedible)
BONES
BY-PRODUCTS MADE BY PACKERS
IN GLASS JARS
CANNED
SAUSAGE
CANNED
SAUSAGE
ILLUMINATING OIL
LUBRICATING OIL
SOAP
GLYCERIN
COSMETICS
GREASE
GLUE
STEAM BONE
ILLUMINATING OIL
MACHINE OIL
CANDLES
STEARIC ACID
POLISHING COMPOUND
BY-PRODUCTS MFD. AFTER LEAVING PACKING PLANTS

FIG. 45

This latter process yields a lower-grade glue water, as well as tallow, and the residue from this pressure cooking is steam bone.

Cattle skulls, jaws, and feet are removed on the killing-floor and are carefully trimmed of all meat before being sent to the bone house. The skulls are split and the brains and other contents removed. The bones are then carefully washed in cold water and may be cooked in open vats for the production of commercial bone, glue, or stick. If cooked for commercial or hard bones, they are carefully air-dried after cooking.

Hoof Grading and Processing

Feet are brought to the bone house and the shins are sawed off just above the knuckle or joint. The feet are then scalded in water just below the boiling point until the hoofs can be separated. The hoofs are dried, ground up, and sold as hoof meal, valuable for fertilizing purposes on account of the high ammonia content. Very white hoofs or very black hoofs, or those that are striped, are saved, if they are in good condition, for they have a considerable commercial value for buttons and imitation ivory products. These hoofs are usually sold to the manufacturers of these products, after being carefully air-dried. Black hoofs are widely used in the manufacture of cyanide of potassium for the extracting of gold.

Hoofs are graded for manufacturers as follows:

No. 1 white hoofs.—All white hoofs weighing 20 lb. and over, per hundred pieces, with an average of 22 lb.

No. 2 white hoofs.—All white hoofs weighing 16–20 lb. per hundred pieces, with an average of 18 lb.

No. 1 black and striped.—When saved, these include hoofs weighing 20 lb. and up per hundred pieces, with an average of 22 lb.

No. 2 black and striped.—When not saved to be calcined (dried), they are the same as the white hoofs, not included in the foregoing specifications.

After shin bones are removed from the knuckles, they are placed in open vats and cooked for four hours at a temperature of

180°–190° F., to separate the neatsfoot oil, meat, etc. The bones are then removed and washed with hot water in a horizontal circular washer to extract the balance of the oil and meat. The neatsfoot oil is skimmed off the contents of the vat and processed, and the cooking water is concentrated in evaporators. The shin bones

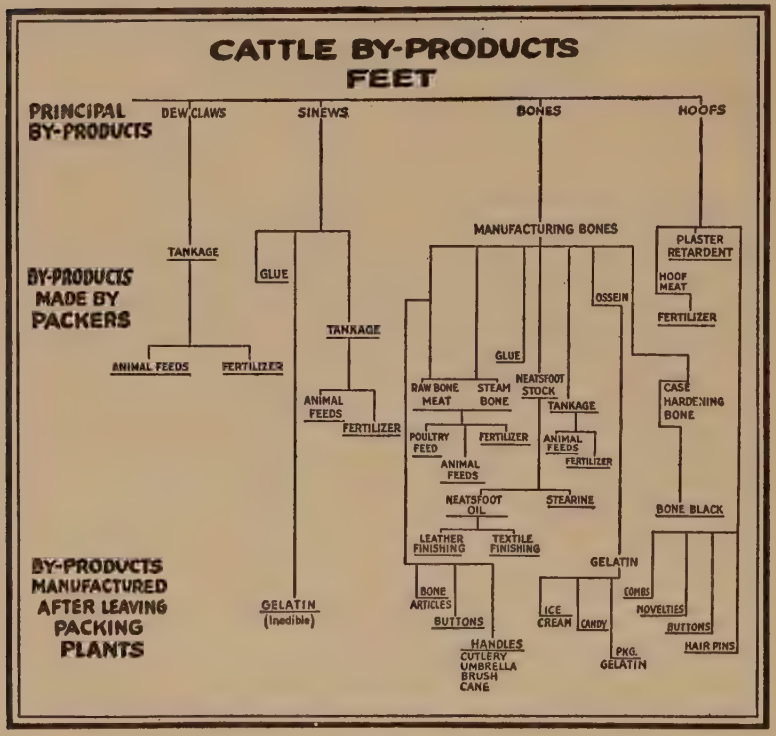


FIG. 46

are then air-dried, are sawed into small flat slabs, and are then shaped by means of saws, lathes, and boring machines into crochet needles, flat buttons, collar buttons, washers, artificial teeth, bone rings for nursing bottles, pipestems, dice, chessmen, electrical bushings, and innumerable other articles, including handles for knives and razors, dyed to resemble stag horns.

Bones from the beef-cutting floor include the blade, rump,

butt, chuck, rib, tail, and shank bones. These bones are carefully inspected to see that no meat is left on them as they come from the cutting floor, for this meat, although valuable for other purposes, possesses little value in the processing of bones; indeed, is rather detrimental. The cutting bones which can be used for hard-bone purposes are cooked in open vats at around 180° F. for the recovery of liquors for beef extract, or for stick and bone oil or tallow. Bone oil is of very high color, and is neutral in flavor. Cutting bones are sawed from the knuckles, leaving the marrow open, and are then given a light scald in very hot water until the marrow is slightly loosened from the bone, and this marrow is then blown out by means of compressed air. After removal of the marrow, the bones are cooked in open vats for about four hours at approximately 180° F., the resultant water being evaporated for beef extract. These cutting bones are classified as the front shank bones, the cannon and blade bones, the hind shank bones, and the buttock and thigh bones. Commercial thigh bones must be 9 inches long or longer. Shin bones are cut from nerve hole to nerve hole, regardless of length. They average, however, about 6 inches long.

The average yield of bones from cutting cattle, per head, is approximately as follows:

	Lb.	Oz.	
2 blade bones	3	2	
2 rump bones	3	6	
2 sets rib bones	8	10	
2 rib blades	4	4	
2 strip bones	6	0	
2 pelves	5	6	
2 chuck bones	11	0	
2 plates	8	4	
2 hind shank knuckles	11	12	
2 fore shank knuckles	9	0	
2 hind shank sawed bones	4	4	
2 fore shank sawed bones	3	0	
Total	75	48	(equivalent to about 78 lb.)

Bones are graded as follows:

Thigh bones.—No. 1 (all thigh bones weighing 86 lb. and up per hundred pieces. They must average 90 lb. per hundred pieces). No. 2 (all thigh bones weighing 66–86 lb. per hundred pieces. They must average 70 lb. per hundred pieces). No. 3 (all thigh bones weighing 60 lb. per hundred pieces).

Buttock bones.—All buttock bones weighing 60 lb. and over per hundred pieces.

Round shins.—No. 1 (all round shin bones weighing 48 lb. and up. They must average 50 lb. per hundred pieces). No. 2 (all round shin bones 38–48 lb. per hundred pieces. They must average 40 lb. per hundred pieces).

Flat shins.—No. 1 (all flat shin bones weighing 38 lb. and up per hundred pieces. They must average 40 lb. per hundred pieces). No. 2 (all flat shin bones weighing 28 lb. and up per hundred pieces. They must average 30 lb. per hundred pieces).

Rejects.—All cracked or spotted or discolored shin bones, thigh bones, and total production of forearm and buttock bones weighing less than 60 lb. per hundred pieces. All round shin bones weighing less than 28 lb. per hundred pieces. All thigh bones weighing less than 60 lb. per hundred pieces.

A great deal of bone cannot be used for commercial bone on account of its size, shape, irregularities in color, cracks, or other causes. Such bone is prepared as hard bone and has a number of very valuable uses, principally the case-hardening of steel. Bone used for this purpose is ground up to the consistency of fine pebbles, and should be hard, clean, and carefully sacked. After use in case-hardening, the bone is usually sold back to the fertilizer plant, where it is used as bone meal, or is burnt or carbonized to bone-black and used as a bleach for oils, fats, waxes, sugar, or pharmaceutical preparations. A bone meal is also prepared from ground bone. This is used as a high-grade fertilizer or for chicken feed. A more coarsely ground bone meal from which the dust of grinding has been eliminated is highly prized as a special food for young chicks.

Hard bone may be further processed by cooking in pressure tanks under 20–40 lb. pressure for about eight hours, or until all of

the remaining marrow and glue has been rendered out and the bone is soft and chalky in appearance. This steam bone, when cooked from good stock, yields about 3 per cent ammonia and 24 per cent phosphoric acid; and when produced from undernourished animals, yields about 2 per cent ammonia and 20 per cent phosphoric acid. The ratio of ammonia to phosphoric acid is increased as the ammonia content increases. The fat rendered in this operation is generally used for edible tallow, and the resultant cooking water is evaporated for glue or stock in essentially the same manner as tankwater. Bone tankage is carefully dried and is used as high-grade fertilizer.

Horn Grading and Uses

Horns are severed from the head by sawing at the meeting place of the skull and horn. They are dropped into a vat of water and are held there at 140°–150° F. for about fifteen minutes, or until the horn pith is sufficiently loosened to permit its removal from the horn. Following this, the horn piths are washed and cooked for about one hour to remove all skin, hair, fat, blood, etc., until they are white and thoroughly cleaned. The piths should be colorless and oderless. They are then cooked in pressure tanks at about 40 lb. pressure, or until all of the grease and gelatinous matter is extracted. The drying of horns requires careful handling. Artificial heat will cause them to crack. They are never dried on steam coils, but are stored in a good, dry room where there is a complete circulation of air.

Horns are graded as follows:

No. 1 steer horns are those weighing 80 lb. per hundred pieces and up. They must average 100 lb. per hundred pieces. The tips must be clear and perfect. If a No. 1 steer horn tip is cracked, scaled, or cut off for commercial purposes, such a horn grades below a No. 2 horn, and not higher than a No. 3.

No. 2 steer horns are those weighing 65–85 lb. per hundred pieces.

No. 3 steer and cow horns are those weighing 30–65 lb. per hundred pieces. No. 3 includes all tipless steer horns.

No. 4 grade includes bull horns, crabs and culls, horns thrown

out from steer horns, and anything not good enough to go into any of the other three grades. They must have at least 3-inch cutting space in length.

Waste includes all stumps and small pieces not good enough for any of the foregoing grades. All horns must be free from dirt and thoroughly air-dried. The horns of cattle can be made supple, be split into thin plates, and pressed in heated molds into diverse forms and receive various colors, thus imitating closely the highest-priced tortoise shell. They can also be made into umbrella handles, knife handles, tobacco boxes, goblets, napkin rings, etc. The comparative scarcity of whalebone has permitted increased use of horn in many sections of the trade formerly supplied by whalebone.

CHAPTER XI

FERTILIZER BY-PRODUCTS

The development of the fertilizer industry as a part of the packing industry afforded a new outlet for certain by-products. Such by-products as were sold as fertilizers were rich in those plant-food elements needed on farms to maintain soil fertility. When larger packers went into the fertilizer business, raw fertilizer minerals were not plentiful and methods of processing were far from perfect. Under such conditions, bone, blood, and tankage ranked high as plant foods, and "from the farm back to the farm" made a popular appeal. The animals had come from the farms and had brought with them in concentrated form, crop after crop of grain and hay. Would it not prove possible now to recover parts of these animals for return to the farm, at little expense? Soils were being depleted year by year, and to meet this situation the fertilizer industry had been established in Europe and in the United States as a compensating factor in restoring and maintaining the fertility of the soil. If animal fertilizers could be made profitable and could be so processed that they could be successfully handled, it was thought that conditions of soil utilization might be improved.

Before the idea of developing a fertilizer industry in direct connection with the packing industry had been evolved, many small renderers utilizing by-products were established around the packing plants. These rendering plants were operated largely by Europeans, who took steer heads, dehorned them, extracted the slugs (insides), prepared the horns for European markets, and converted the leftovers into glue, fertilizers, and other products. They also prepared bones for export markets, and extracted the glue and fats from the trimmings, selling the residue for fertilizer materials. Most of these waste materials, consisting of entrails, livers, hearts, shanks, heads, hoofs, tails, and trimmings of hides and scrapings

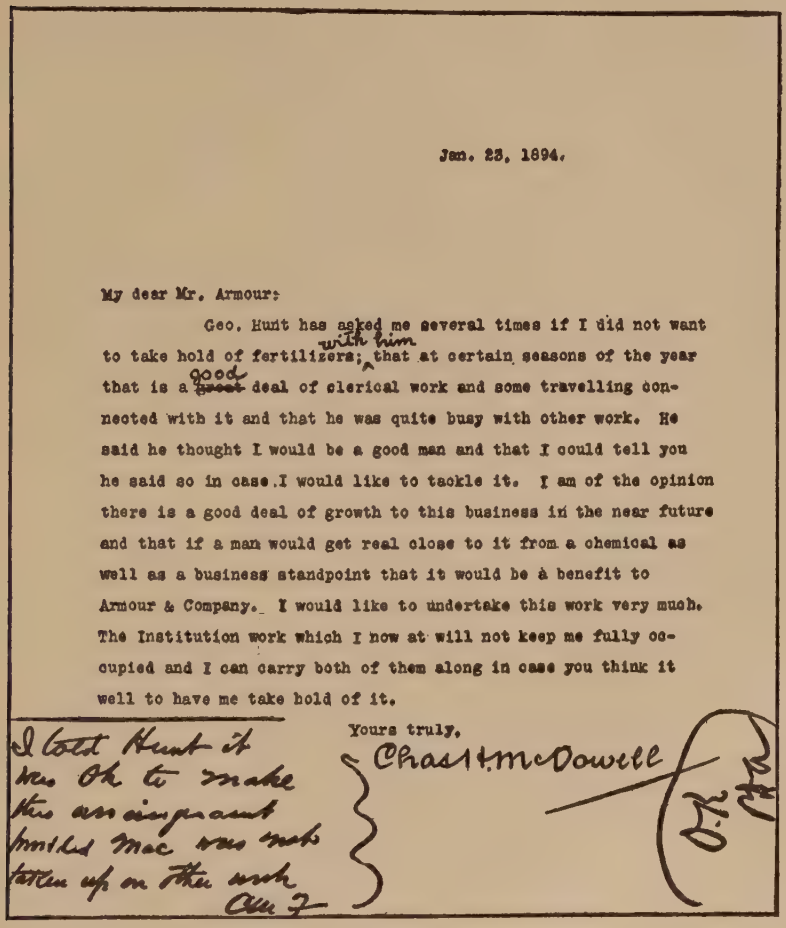
from the hogs, were at first given away to these rendering plants for the hauling. Later, charges were made, and this eventually grew into a by-products business.

These small rendering plants helped the packers to develop habits of thrift, and prepared for the development of a large-scale by-product industry. Regarding animal-fertilizer materials, the difficulty of the packer was in adapting them to a form in which they could be shipped and handled on the farm. One problem was to make the by-products dry enough for practical use on farms. With bones this was easy; but with offal it was a serious matter. Crude drying machines were devised, and when the grease had been taken off, the residue was run into a dryer. This dried material was called "tankage," and for years was sold to fertilizer manufacturers as fertilizer raw material. But buyers would take the material only in such quantities as they chose, leaving the packers with large amounts of such products for which they had no market, thus forcing large price reductions for summer shipment or large investments for storage facilities. At first tankage was sold unground, but later packers installed mills and ground the materials, thereby adding greatly to their value.

The sale of blood, bone, and tankage eventually became a regular feature of the packing business, and these materials were recognized fertilizer ingredients in the American trade. This machine-dried tankage was first put out by Chicago packers about 1880 before which time no packer had gone actively into the fertilizer business. All of them had previously sold blood, bone, and tankage to fertilizer manufacturers and dealers.

During the World's Columbian Exposition at Chicago in 1893, however, packers themselves first thought seriously of making fertilizers. At the Exposition was a fertilizer exhibit which attracted wide attention and showed the possibilities of the industry, whether operated independently or in connection with the packing industry. In that year C. H. MacDowell, of Armour & Company, was permitted by P. D. Armour to enter the fertilizer industry as an experiment, as the accompanying letter indicates. The experiment was a great success, and opened the way for others to follow.

From that time fertilizers have been one of the allied activities of the American meat-packing industry.



Jan. 23, 1894.

My dear Mr. Armour:

Geo. Hunt has asked me several times if I did not want to take hold of fertilizers; with him that at certain seasons of the year that is a ~~great~~ good deal of clerical work and some travelling connected with it and that he was quite busy with other work. He said he thought I would be a good man and that I could tell you he said so in case I would like to tackle it. I am of the opinion there is a good deal of growth to this business in the near future and that if a man would get real close to it from a chemical as well as a business standpoint that it would be a benefit to Armour & Company. I would like to undertake this work very much. The Institution work which I now at will not keep me fully occupied and I can carry both of them along in case you think it well to have me take hold of it.

Yours truly,

Chas H. McDowell

I told Hunt it was Ok to make this arrangement provided Mac was not taken up on other work
Am F

FIG. 47

In the nineties most of the by-products of the packing plants went into fertilizers, but since then at least 90 per cent of the high-grade tankage, and 75 per cent of the blood manufactured by the national packers, has gradually found its way into the market as animal feeds. This has been brought about by close co-operation

with state agricultural experiment stations in their research work on feeds and animal nutrition. No large tonnage of packing-house by-products goes into fertilizers at the present time. While these materials have gradually found their way into other channels, however, the fertilizer plants belonging to the packing plants have continued to develop trade and to find mineral substitutes for packing-house materials, and the fertilizer business itself has developed into the largest of the heavy chemical industries. So that what started out as an industry to dispose of the packing-house by-products has grown largely out of this into a pure chemical industry. Fortunately, plants that were built in the early history of the industry were easily adjusted to more modern needs, and the whole development has been a matter of natural and inevitable evolution.

The three essential elements in commercial fertilizer are: (*a*) nitrogen, the chief sources of which are sulphate of ammonia, nitrate of soda, cyanamid, nitrate of lime, as well as certain organic materials; (*b*) phosphates, the principal form of which is acid phosphate, which are the chief carriers of phosphoric acid; (*c*) potassium, which is normally used by the trade as potassium salts or potash.

Mixed fertilizer is made by combination formulas from these three elements.

Sources of Animal Fertilizer

As has been indicated, animal fertilizer materials came from various parts of the animal, including bones, hoofs, blood, tankage, and tankwater. It is of interest to consider these sources further:

Bone.—A good deal of bone meal still goes into fertilizer, though much of the better grades goes into feeds. Bone itself is disposed of in different ways. Soft bone may go direct to the glue works, and then after the glue stock has been extracted, the residual bone meal is put into fertilizer. Harder bones, especially round and flat shins, and thigh bones, which are called manufacturing bones, may go into manufactured bone by-products, such as knife

handles, etc. The scrap from these is ground and put into feeding bone and case-hardening bone. Again, bones may be burned into charcoal and used in sugar and oil refining until spent, and then made into fertilizer or feed. Incidentally, in the charring process, bones distill off ammonia, and this is made into sulphate of ammonia for fertilizer. The fine bone charcoal dust goes into pigment for paints, artificial leather, fabrikoid, automobile tires, etc.

Bone is manufactured into two kinds of bone meal: (1) raw (i.e., cooked in an open tank), and (2) steamed (cooked under steam pressure). Both of these processes for making meal have the same aim, viz., to extract the grease.

Blood.—Blood is the source of a variety of products. For example, it is made into edible and inedible albumen, and a certain amount goes into an animal feed (blood flour), which is particularly good for calf meals, in which form it is a recognized remedy for scours. A good deal of blood is an ingredient of fertilizers for special crops, such as citrus fruits, and truck and tobacco crops.

Tankage.—At present about 95 per cent of all high-grade tankage finds its way into feeds. For the feeding laws of various states prescribe that feeds must be free from horns, hoofs, and hair, and so they cannot be used for feed. Some lower-analysis tankage goes into fertilizer, as it would not be satisfactory for feeding, especially tankage from stomach contents and black guts. In the high grades, hair tankage, when properly processed, makes good fertilizer tankage. "Nitrogenous" tankage is made from leather scrap, which, with fleshings from hides processed, are turned into fertilizer. Tankage is also made from the trimmings of sheep waste. Wool scourings are incorporated in fertilizer because of their potash content.

Hoofmeal and hornmeal.—These are used for fertilizer, although white hoofs may be made into buttons. All waste and black hoofs are calcined and ground into hoof meal, which has high nitrogen content. Likewise, pig toes are processed into bone or other fertilizer tankage.

Tankwater.—Tankwater is evaporated and dried, and is then used for fertilizer material or feed; mostly for feeds.

Tankage.—Tankage is a meal of brownish color and distinctive odor. There are various grades, depending largely upon the proportion of flesh and bones used. The standard high-grade tankage in the Chicago market contains from 9½ to 11 per cent ammonia (7.8 to 9.0 per cent of nitrogen), and from 12 to 20 per cent of bone phosphate of lime. Lower grades of tankage contain less ammonia and more of bone phosphate. When mixed with the soil, tankage decomposes more slowly than dried blood, so that it furnishes food to plants over a longer period.

A large variety of waste materials, e. g., leather scraps and fleshings, hair, fur, felt, etc., are utilized by a number of concerns in making so-called "tankages" sold under special brands or names. Some of these materials are also used directly in making base goods. Packers' tankage is produced from meat scraps, intestines, bones, carcasses of dead and condemned animals, etc., by cooking in specially constructed tanks under steam pressure of about 40 lb. for from 4 to 12 hours, the average time being from 6 to 8 hours. After most of the grease and tallow have been removed from the cooked mass, the solid material is separated from the tankwater and dried and ground. Tankage thus prepared still contains from 10 to 20 per cent of grease, which it has been found profitable to extract before using for fertilizer. A number of concerns are engaged in making this extraction, naphtha being used as the degreasing agent.

Formerly, tankwater was allowed to run to waste, but now it is collected into vacuum pans or evaporators, and reduced to the consistency of molasses. In this form it is known as "stick." It is then mixed with tankage and dried. Until recently it was dried by itself on large hot rollers, in which case it was called concentrated tankage or "dried stick." The ammonia content of this material ranges from 14 to 15 per cent, but on account of its unstable mechanical condition and difficulties in handling, it is not considered, from a manufacturing standpoint, as being as desirable for fertilizer as tankage and dried blood.

Dried blood, as prepared for fertilizer, is a dark reddish meal or powder containing about 17 per cent of ammonia, equivalent to

about 14 per cent of nitrogen. When applied to the soil it decomposes readily, releasing ammonia that is converted into nitrates by soil bacteria, which are later, in their turn, to be utilized by plants. The rapidity of the decomposition depends upon such factors as the character of the soil, temperature, etc. This product has a high fertilizer value.

Dried blood is prepared by a process of coagulating, drying, and grinding. The blood flowing from the slaughtered animals is conveyed as soon as possible into vats, where it is heated by means of steam until coagulated. It is then placed in press cloths, and as much moisture as possible is extracted by high-power presses, after which it is passed through driers until the moisture remaining constitutes but 5–10 per cent of its weight. The grinding process consists in passing the material through a cage mill, which breaks up the small lumps so that the whole mass is in suitable condition for fertilizer purposes. Many *abattoirs* do not have facilities for preparing dried blood, and at such plants the blood is run in with the tankage.

A Modern Fertilizer Factory

Until a few years ago labor-saving machinery was unknown in the fertilizer factory. Men were plentiful and wages reasonable. A typical fertilizer plant was a large building, down the center of which was a section built like the capital letter "A," widely spread. This was entirely occupied by the acid phosphate pile. On each side were bins of various kinds of tankages, blood, potash salts, etc., that went to make up the various kinds of fertilizers. Beyond these were the mills for mixing, screening, and bagging. An army of men was necessary to move the several hundred tons of material which each day had to be shipped out. The piles had to be picked loose by hand, shoveled into wheelbarrows, rolled to the scales, weighed, and then dumped into the machines. A plant shipping a thousand tons of mixed fertilizer a day required some 150 men to put the raw materials into the machines, not including the men necessary to mix, screen, and bag and load it. Scarcity and relative inefficiency of labor, as well as current wage rates, has

necessitated the introduction of labor-saving machinery into new factories.

Modern practice in fertilizer construction requires steel buildings, every point of which is reached by traveling overhead cranes carrying grab buckets capable of picking up two or three tons of material at a time. A row of large 10-ton hoppers stretches across the building opposite each mill. Under each large hopper is a small weighing hopper, and under the weighing hopper a belt conveyor running to the mill. The overhead cranes keep the large hoppers filled with various raw materials. The proper amount of each material per ton of fertilizer is weighed out into the small hoppers underneath, and this is then dumped onto the belt and conveyed to the mill. With this system, twenty men can easily handle a thousand tons a day in the machines, a saving of 86 per cent over the old method in the size of the labor force. This type of factory costs a great deal more than the old type, and the small working force commands salaries in place of wages. Therefore there is little saving, if any, in the cost of manufacture. But with the modern plant it is possible to ship the fertilizer when farmers want it, and this is often not so easily possible with the old-type plants under present labor conditions.

Close chemical control of manufacture is maintained in a modern fertilizer plant. The material is analyzed as it comes in, formulas are prepared based on these analyses, the goods are mixed, and are again analyzed before shipment. A complete record is kept, so that the analysis of each ingredient and of the finished product is on call for reference purposes. Check samples of all goods are kept for reanalysis at any time.

Fertilizer manufacturers advocate strongly a reduction in the number of brands manufactured, and they are attempting to standardize, as far as possible, the grades shipped. This standardization makes for economy in manufacture and increased speed in shipping. In times past a demand was created for many different analyses to meet competition, since users have had their own ideas as to what they wanted; and the result has been the making and selling of many analysis mixtures. Standardization will gradually

do away with so many brands, and it will tend to the better, less expensive, and more intelligent manufacture of fertilizers.

Manufacturers are also urging consumers to use higher-grade goods than has been the custom in the past. There has been a tendency, both on the part of the fertilizer salesman and the consumer of fertilizers, to recommend rather low-analysis goods because they are cheaper per ton. This is not good practice, as it is more expensive per ton of plant food to make, bag, and ship low-analysis goods than it is to prepare, bag, and ship goods containing more pounds of plant food. It is a waste of money, and the fertilizer consumer pays; for it is to his advantage to buy more concentrated fertilizers. The standardized grades mentioned are higher-grade goods. It is the natural desire of the fertilizer manufacturer to give the consumer what he wants; but there is no question that low-analysis goods are more expensive per pound of plant food than more concentrated brands.

Marketing of Fertilizer

The greater part of the output of tankage and dried blood in the United States is sold through brokers, who make a specialty of fertilizer materials. The usual brokerage commission on tankage and blood, which is always paid by the seller, is 25 cents per net ton.

Formerly, packing-house fertilizer materials were sold to the trade at a flat rate per ton, but today the price is based on the units of ammonia contained, as determined by chemical analysis; a unit being 1 per cent of a net ton, or 20 lb. The ammonia content in such materials varies considerably, and it is more satisfactory to all parties to have sales made on the unit basis, the buyer paying for what each lot analyzes.

A low fixed price of 10 cents per unit is taken as a basis to govern the value of bone phosphate, while the unit price of the ammonia content is determined by market conditions. Thus $2.75 and 10 cents would mean that the ammonia is to be billed at $2.75 each unit or per cent (20 lb.), and the bone phosphate at 10 cents each unit or per cent in a ton. At this price, tankage analyzing 9

per cent ammonia and 20 per cent bone phosphate would sell for 9×$2.75 plus 20×$0.10, or $26.75 per ton. On sales by larger packers the weighing and sampling are always done at the point of shipment. The buyer usually has the privilege of having a representative present, or, upon notice, will be allowed board of trade weights at time of loading, the expense of which is borne by the buyer and seller when so agreed upon. The method of sampling is of great importance. It is usually done by taking a small quantity from each cart load, if in bulk, or from each bag as loaded into the car. The sample is then thoroughly mixed, and a certain quantity is placed in containers and sealed, one for the seller's laboratory and another for the buyer.

The terms of settlement for sale of tankage and dried blood vary somewhat. Chicago packers, all of whom are equipped with laboratories, usually draw a sight draft for the full amount of the invoice, with bill of lading and certificate of analysis attached. The practice of small Eastern *abattoirs*, which are not usually equipped with laboratories, is to draw for three-quarters of the standard value, the balance being settled on receipt of the chemist's analysis.

Usually the buyer purchases on a cost and freight basis. The advantage is that the buyer knows just what it costs him per unit at his plant. In general, the method of fertilizer distribution is to send concentrated material, e.g., sulphuric acid, rock phosphates, potashes, and ammoniates, to the various fertilizer plants situated for the most part in tidewater regions from Maine to the Gulf, where finished fertilizers are manufactured and shipped to nearby points, and then freight charges are saved.

Commercial fertilizers are distributed generally to farmers by means of merchant dealers, though some are sold through farmers' co-operative associations. The period of heaviest selling of fertilizers is in the spring, and the trend is toward a still shorter shipping season than at present.

The marketing of fertilizers by national packers is a specific problem by itself. Fertilizer cannot be sold through the regular channels of the packer trade; since tanners, retail meat shops, and

grocers do not handle fertilizer. Therefore packers have to sell fertilizer to farmers, who buy mostly in the spring. Farmers are reached through local dealers in country towns, to whom packers sell direct. Some local dealers own general stores; others are feed dealers. In some cases in the South, packers sell through cotton warehouses, and in the grain section, through country elevators. Any marketing channel is utilized that places the fertilizer in farmers' hands at the lowest price and at the best time.

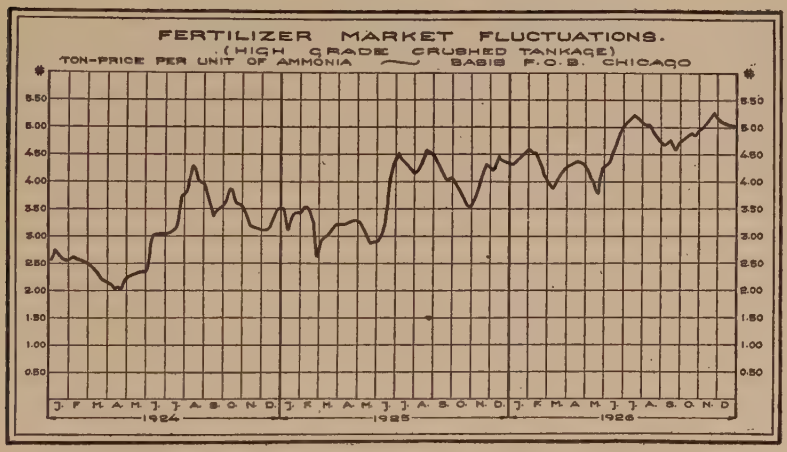


FIG. 48

The business of the fertilizer industry is to purvey plant food. Competition has forced the manufacturer to standardize his product into different grades, according to analysis. In a given grade, differences in price mean nothing in the unit value of the fertilizer materials. A ton of a standard-analysis fertilizer at a high price will not produce a greater yield than a ton of the same grade at a low price. High values and high prices too often mean merely increased vicissitudes in doing business. The relation between wholesale prices of fertilizer materials and wholesale prices of other commodities, including agricultural products, are shown in the accompanying graph. It is apparent that while farm products have a lower purchasing power than an average of all commodities, fertilizer materials have a still lower purchasing power than

farm products. In fact, at present prices the latter will purchase more fertilizer than they would in 1913.

Among the factors which exert an important influence upon the prices of all ammoniates are the ready substitution of one for the other, the increased use of cottonseed meal and tankage for stock feed in recent years, and the varying demand for fertilizers, especially in the cotton states, which is influenced by the price of cotton.

The prices of tankage and dried blood appear to be particularly affected by the prices of cotton and of cottonseed meal. Major price fluctuations in tankage and dried blood follow from eight months to one year after major price movements in cottonseed meal. There is a marked similarity between the course of cotton prices and those of tankage and dried blood. For example, if cotton is high, due to a short crop, the use of mixed fertilizers is stimulated. On the other hand, a shortage of cottonseed meal raises prices for the other organic ammoniates, which compete in the animal feed and fertilizer industries.

In the case of tankage, there are wide fluctuations in price between the quiet and active seasons. Tankage and dried-blood prices usually have a break in the summer months and a recovery in the autumn. Again, volume of livestock production and slaughter is an important factor governing tankage prices. For example, since 1920, prices of hogs have fluctuated widely. When hog prices fell very low and producers' incomes shrank, fertilizer could not be bought and paid for until prices dropped enough to meet the producers' ability to pay. Thus, fertilizer prices are influenced to some extent by livestock prices and those of other farm products. Finally, when fertilizer prices in general are low, tankage will be put to alternative use, e.g., for animal feeds, where better prices can be obtained. National packers store fertilizer materials during the summer, and this storage of tankage tends to stabilize the general tankage market.

CHAPTER XII

ANIMAL AND POULTRY FEEDS

At the present time, approximately all of the residues from the large packing plants go into animal feeds, rather than fertilizers. This situation has brought better prices to packers for their meat residues, while it has resulted in better feeds for the livestock and poultry producer. Great numbers of breeders and feeders of livestock no longer attempt to raise and fatten stock without making

TABLE XXIV

	Protein (Percentage)	Fat (Percentage)	Bone Phosphate of Lime (Percentage)
Meat meal (tankage)	50–60	5–10	21.85 (maximum)
Meat scrap (cracklings)	50–60	5–10	21.85 (maximum)
Meat and bone meal or scrap	40–50	5–10	21.85 (minimum)
Blood meal	80–85	.....	.....
Poultry bone (in various sizes)	20–25	3	40–50
Pure raw bone meal	20–25	3	40–50
Special feeding bone meal	5–10	.....	65 (minimum)

use of some of the essential supplemental feeds produced from the residue of the large packing plants. These supplementary animal feeds include meat meal (feeding tankage), meat scraps, meat and bone, blood meal, pure raw bone feeding meal, and special steamed bone meal. Beginning with poultry, where it was found some thirty-five years ago that egg production was considerably increased if a certain percentage of crushed green bones and chopped meat was fed in conjunction with their grain ration, meat packers have developed a large business of drying and grinding tankage and cracklings for hog feeds. Hogs crave meat proteins, and about two decades ago experiments showed that meat residue mixed with ordinary corn made hogs gain weight faster than corn alone. Furthermore, feeding meat residue to brood sows regulated their disordered appetites and prevented them from eating their newborn pigs.

These animal feeds are sold at present according to analysis and feeding value. In meat residues there are three of the necessary compounds of nutrition: protein, fat, and minerals. Bone gives lime and phosphate for bone and tissue growth. Protein is supplied in concentrated form in tankage and dried blood. Fat is present in all these residues. The typical grades of commercial meat residues are shown in Table XXIV.

Meat Meal or Digester Tankage

Meat meal is ground dried residue, after partially extracting the fats and oils from animal tissues, exclusive of hoof, horn, manure, and stomach contents, and does not contain more than 10 per cent of phosphoric acid. In case the amount of phosphoric acid is over 10 per cent, the product is known as meat and bone meal. At present, commercial meat meal may be either tankage or cracklings. Mixed-feed manufacturers use it as a material in making hog, poultry, and other feeds. When finely ground it is used in various mashes.

Tankage itself is a finely ground, meaty substance varying from light to dark brown in color and bearing the odor of cooked meat when fresh. It will keep indefinitely as long as it remains dry. It consists of the residue of animal tissues, exclusive of hoof and horn, etc., especially prepared for feeding purposes. For six to eight hours these raw materials are tanked under live steam at a pressure of 20–60 lb. in a large cone-bottomed vertical tank. The resulting products are fat and grease, which are skimmed off the top of the charge, a liquid or liquor which is drained off, and solid matter which is dropped into a press. This liquor, which averages 4 per cent solids and 96 per cent water, is fed to a large triple-effect evaporator; the moisture is reduced to 50 per cent, and the result is a thick, gluey substance called liquid stick, containing about 45 per cent protein. The solid matter is put in a steam dryer at a pressure of 80–100 lb., the liquid stock is added, and the whole mixture is agitated until the moisture content has fallen to 8 per cent. The product is tankage, which is dumped out, allowed to cool, and finally ground and bagged for shipment.

From this tankage is prepared meat meal, known in some trade circles as digester tankage. This digester tankage is the residue from animal tissues, exclusive of hoof, horn, manure, and stomach contents, especially prepared for feeding purposes by tanking under live steam and by suitable drying and rendering. It does not contain more than 10 per cent of phosphoric acid. If this product contains more than 10 per cent of phosphoric acid, it is designated as meat and bone digester tankage. The commercial feed, digester tankage, is a dark, reddish-brown substance, ground somewhat finer than corn chop, and yet not as fine as middlings or shorts. It is dry, and if maintained in dry storage, will keep indefinitely.

Meat meal is the fresh meat residue from slaughter-houses. The clean meat offal is cooked for eight hours under live steam pressure of 40 lb. in steel tanks, to separate the fats and oils from the tissue. The residue goes from the tanks to hydraulic presses to free it from oils and moisture, and is then dried in steam-jacketed driers for eight hours under high heat, which provides for thorough sterilization. After this it is milled, screened, and packed in 100-lb. net weight burlap bags. Long cooking and drying thoroughly sterilize these feed products, destroying all living organisms that may have been in the raw materials. This insures against any possible infection, and at the same time renders the materials palatable and quickly digestible. A good meat meal feeding tankage analyzes not less than 60 per cent protein, 6 per cent fat, and not more than 2 per cent crude fiber. It also contains 7–10 per cent bone phosphate, and is free from hoofs, horns, hair, and stomach contents.

Meat meal, if properly made, is palatable and a great appetizer for hogs. They relish meat meal because it is made from fresh meat products, and all swine, being omnivorous, are naturally meat-eaters. Unfortunately, their craving for meat is often satisfied at the expense of chickens, or the eating of young pigs and other farm animals. The feeding value of any ration is determined largely by the digestible matter it contains, and the digestible protein produces flesh, bone, and muscle, and promotes rapid and healthy growth. That is why a tankage-fed hog will show a gain

of from 1½ to over 2 pounds per day, as compared to a gain of from three-quarters of a pound to one pound per day when fed corn alone. Protein in meat meal is practically all digestible and contains about nine times the amount of protein contained in the same weight of corn.

Cracklings

The name "cracklings" still refers to the residue product after partially extracting the fat and oils from animal tissues, exclusive of hoof, horn, manure, and stomach contents, by an open-kettle or dry-rendering process. By the more recent method known as dry rendering, the raw material is cooked in a fat-melter, which is a steam-jacketed vessel with paddles as agitators. The moisture is driven off, the excess melted fat is drained off, and the solid matter is put into a screw press where the grease content is cut down to about 8 per cent. The resulting product is then granulated into a scrap, or ground into meal. This dry-rendering process produces a better product than tanking. Due to quicker handling, decomposition is less likely. The feed has a lighter color; it is practically non-odorous; it shows a higher analysis record; and it keeps well. Cracklings are thus used for poultry and hog feeds, and are also blended by mixed-feed dealers with grain mixtures for scratch feeds, mashes, etc. When free from bone it makes a good dog feed and dog biscuit ingredient.

Pure Raw Bone Feeding Meal

Pure raw bone feeding meal is a white ground raw bone made only from the bones of cattle from killing-floors. No sheep or hog bones are normally used. The bones are cooked in boiling water in open vats for about eight hours to free them from tissue, and are then thoroughly dried, assuring a sterilized product. At this point the bones are ground and screened into several granulations, bagged in 100-lb. net weight burlap bags, and are then ready for the feeder. Good pure raw bone feeding meal is manufactured especially for feeding purposes, is guaranteed to have been thoroughly sterilized, and analyzes not less than 23 per cent protein, 48 per cent bone phosphate of lime, 3 per cent fat and not over 2 per cent crude fiber.

This raw bone feeding meal is the mineral element that goes with other feeds. The protein in it will supplement other proteins, but efficient feeders do not try to get a total protein ration from bone meal. It supplements the diet for horses, cattle, hogs, sheep, and poultry, but each class of animal requires a different percentage of bone meal in the several diets. The following is a good guide:

With the regular feeds of horses should be added from two to six ounces of pure raw bone feeding meal per day for each horse. Mares with foal or suckling colts should have double this amount in the daily ration, and the colts should receive daily as much per hundredweight as the mother. For calves, pure raw bone feeding meal can constitute 2 per cent of the total weight of the concentrates, and for dairy cows and pregnant cows, the same percentage. For other cattle, slightly smaller amounts are sufficient. The bone should be mixed in with the other feeds at feeding time, or in bulk, to suit the convenience of the feeders. Young pigs running in the open should be fed pure raw bone feeding meal in the proportion of about $2\frac{1}{2}$ per cent of the total weight of the feed. The quantity of pure raw bone feeding meal for hogs should be increased to at least one part of feeding bone meal to ten parts of the total weight of the ration fed. In most cases feeding bone meal is more readily eaten when flavored with about 10 per cent meat meal. The meat meal and raw bone feeding meal are mixed, and then the balance of the ration in the foregoing proportions is added. Sheep are kept in much better condition when small quantities of raw bone are added to the regular ration. It is usually more difficult to get sheep to eat mineral feeds than other animals, but there will be no difficulty in this respect with tasteless and odorless raw bone meal. A decided advantage is found in the use of small amounts of bone meal in sheep diet.

No class of livestock responds so readily to bone as poultry. They demand larger amounts of calcium than other livestock, and hence show greater gains from bone meal. For chicks there may be used one part of bone meal to every seven parts of the other diets, and to this, one-fourth of one part of charcoal may be added. Chicks multiply their original weight about eighteen times in the first ten weeks if the feeds contain the right proportion of the foregoing minerals. For laying hens the same proportion may be used. For finishing for market, one can use one part of bone meal to ten parts of other mixtures, adding to this amount the same amount of charcoal.

Poultry Bone

For the making of poultry bone, hard cattle bones are boiled with steam for eight to twelve hours. They are then cleaned and

whitened by being put in a revolving washer with fresh water, which sets free all meat and tendons. On being dried they are ground and separated into chicken size, pullet size, and hen size. This bone, consisting mostly of phosphate of lime, provides the nutriment for making eggshells. Poultry bone is made especially for feeding poultry, and in three granulations: fine granulation, about the same as corn meal, used for small chicks; medium granulation, a little larger than a kernel of rice, largely for growing chicks and self-feeders; coarse granulation, about the size of a kernel of corn, for scratch feed, also self-feeders.

Blood Meal

Blood meal is ground dried blood. In preparing it, blood is coagulated or cooked by means of live steam in steel tanks, and the moisture is reduced in a hydraulic press, and a steam drier at high temperature until all possible germs are destroyed and the product becomes a dark red powder. It is then ground and bagged for shipment. This is 97 per cent digestible and is the highest protein feed on the market. In good dry storage it will keep for years. While blood by itself causes severe constipation in hogs or poultry, it is an excellent high-protein ingredient in mixed feeds. When fed with milk it cures the disease known as "scours" in young calves, and is widely used in most calf feeds. While blood meal is a practical feed for poultry, calves, colts, and lambs, and runs higher in protein than any other feed, when used as a hog feed it must be supplemented with mineral elements necessary for growing bone. Blood meal is useful for run-down and thin horses, and from $\frac{1}{2}$ to 1 lb. may be used daily in mash feed for hard-worked horses. Good results have been obtained by feeding dried blood to lambs as a supplement to milk, supplying $\frac{1}{2}$ lb. daily for each hundred pounds of live weight. The Iowa Experiment Station fed one lot of hogs for sixty days, feeding a combination of corn in one feeder and blood meal in another. Hogs eating what they wanted gained about $2\frac{1}{8}$ lb. daily on a ration of 9 lb. of corn, a little over $\frac{1}{2}$ lb. of blood meal, and a small amount of salt. The feed required for 100 lb. gained was 435.85 lb. total, including

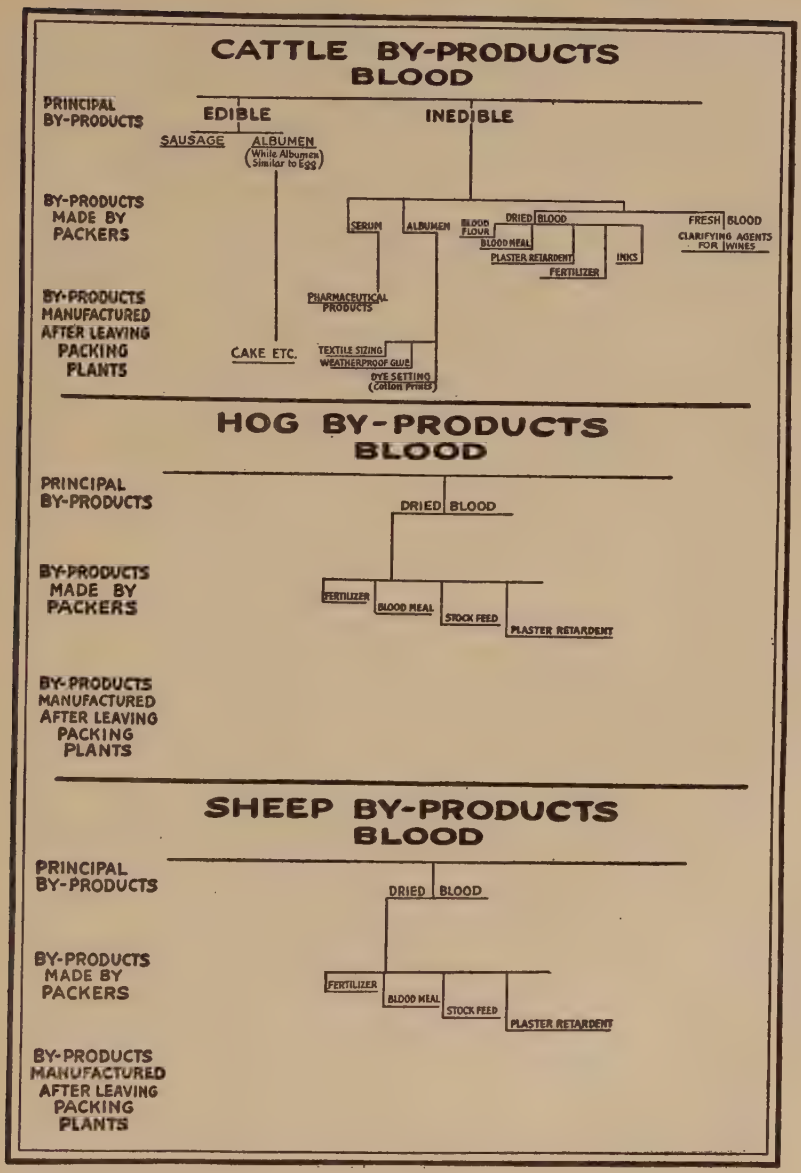

CATTLE BY-PRODUCTS
BLOOD
PRINCIPAL BY-PRODUCTS
EDIBLE
INEDIBLE
SAUSAGE
ALBUMEN
(White Albumen Similar to Egg)
BY-PRODUCTS MADE BY PACKERS
SERUM
ALBUMEN
BLOOD FLOUR
DRIED BLOOD
BLOOD MEAL
PLASTER RETARDENT
FERTILIZER
INKS
FRESH BLOOD
CLARIFYING AGENTS FOR WINES
BY-PRODUCTS MANUFACTURED AFTER LEAVING PACKING PLANTS
PHARMACEUTICAL PRODUCTS
CAKE ETC.
TEXTILE SIZING
WEATHERPROOF GLUE
DYE SETTING (Cotton Prints)
HOG BY-PRODUCTS
BLOOD
PRINCIPAL BY-PRODUCTS
DRIED BLOOD
BY-PRODUCTS MADE BY PACKERS
FERTILIZER
BLOOD MEAL
STOCK FEED
PLASTER RETARDENT
BY-PRODUCTS MANUFACTURED AFTER LEAVING PACKING PLANTS
SHEEP BY-PRODUCTS
BLOOD
PRINCIPAL BY-PRODUCTS
DRIED BLOOD
BY-PRODUCTS MADE BY PACKERS
FERTILIZER
BLOOD MEAL
STOCK FEED
PLASTER RETARDENT
BY-PRODUCTS MANUFACTURED AFTER LEAVING PACKING PLANTS

FIG. 49

409.5 lb. of corn, 25.34 lb. of blood meal, and 1 lb. of salt. The significant point is the very small proportion of blood used.

Blood meal is a sure preventive, and is almost always a cure, for scours in calves and young animals. A teaspoonful in the milk at each feeding three times a day will usually be sufficient. It has been found that sickly calves given at first a teaspoonful, and later a tablespoon, of dried blood with their allowance of skim milk rapidly regain their health; but in all cases the blood should be carefully incorporated with the milk, to prevent settling. Again, 1–2 lb. of dried blood per head daily with other concentrates is sufficient for dairy and beef cattle. When it is desired to increase the protein content of mixed mash, blood meal supplies this in the best and cheapest form, beginning with a 2 per cent and increasing to 5 per cent.

Meat Scrap

Meat scrap is ground and screened cracklings. It does not contain over 10 per cent of phosphoric acid. If the product contains more than 10 per cent phosphoric acid, it is called meat and bone scrap. Meat scrap is made from cracklings, and, with most manufacturers, carries the guaranty of 50 per cent protein, 6 per cent fat, and not over 2 per cent crude fiber. The only difference is the granulation. Both products are purely meat residue, containing 10–25 per cent bone phosphate of lime. Meat scraps are made in three granulations, the fine granulation, or chick size, being about the size of a kernel of rice; the medium granulation, a little smaller than a navy bean; and the coarse granulation, about the size of a kernel of corn, for adult poultry. The meat scraps are unexcelled for scratch feeds.

Meat and bone scrap is a special mixture composed of crackling scraps and raw bone. The usual guaranty is 50 per cent protein, 20 per cent bone phosphate of lime, 6 per cent fat, and not over 2 per cent crude fiber. This product is practically odorless and tasteless, and supplies protein for rapid growth and egg making, as well as bone phosphate for bone and eggshell builder. Authorities agree that a chick cannot develop rapidly, and a hen

cannot lay the maximum number of eggs, unless she gets a ration balanced with meat and bone, meat meal, meat scraps, or pure raw bone. In an egg-laying contest conducted by the A. and M. College of Texas, the following ration has been found very satisfactory: Mash, fed dry in hoppers available all day; made up of wheat bran, 15 lb.; corn meal, 30 lb., ground milo, 35 lb.; meat scrap, 20 lb.; scratch grain, fed in litter morning and night; whole corn, 40 lb.; oats, 15 lb.; whole milo, 45 lb.

Special Steamed Bone Meal

Special steamed bone meal is of light color, free from objectionable odor, and supplies the bone phosphate of lime that is deficient in most grain feeds. It is guaranteed to have a minimum of 65 per cent bone phosphate of lime. Domestic animals eat it readily, either alone or mixed with other feeds. Special steamed bone meal is desirable for use in feeding mixtures where a high percentage of bone phosphate of lime is required to produce quick growth in young stock, and to supply the heavy bone phosphate of lime requirements for egg production.

Cattle get out of condition enduring certain vicissitudes, such as drouth, pasturing on land that has been closely grazed year after year, or dry lot feeding, which at best is unnatural. Many cattle men have experienced the results of "creeps," loin disease, etc., and even where such definite diseases do not materialize, they have had certain animals that would not maintain the proper growth and development. Many are familiar with the series of experiments that have led scientists to believe that these back diseases and bad conditions come from a lack of mineral salts in the grass, and that in most cases these health-giving minerals are lacking because the pastures have been grazed year after year until not enough vegetation goes back into the soil each season to give the succeeding grass crop the nourishment it needs.

Therefore some way was sought to overcome the effect of this lack of minerals in the grass. As animal bones are always of mineral composition, and as it was noted that the cattle would almost invariably try to eat any bones left in their reach, disease-free

bones were procured in a sanitary manner, ground into edible form, and this bone meal was fed to the cattle.

There are very definite conditions of an evolutionary nature affecting animal and poultry feeds which are produced as a result of packing-house operations. Some phases of this evolutionary period may well be noted: First, the efforts of the state experiment stations, and the continuing advances in scientific investigation which bring forth new facts, are resulting in new forms of feeds, such as mineral feeds, and feeds of different characters which are of greater value for various feeding purposes. The information thus broadcast to the ultimate consumer by the agricultural colleges has, in turn, its effect in creating keener demand, due to the advancement in feeding science. Second, the present evolutionary period in the production of packing-house feed residues, as the result of the change from wet or pressure rendering to the dry-melter system of rendering, results in a proportional increase of a less odorous crackling form of residue, more concentrated and more adaptable for all forms of feeding.

This dry-melter production of cracklings decreases proportionally the production of the pressure-rendered product known as the digester tankage or meat meal. Agricultural experiment tests thus far completed show, for example, that the crackling dry-melter product analyzing 50 per cent protein and containing a minimum of 20 per cent bone phosphate of lime gives much better feeding results, showing greater gains at less cost when compared with 60 per cent protein meat meal containing a maximum of 20 per cent bone phosphate of lime. The increased demand, due to its value as a feed for general health, rapid gain, and bone building affords a ready market. This, in turn, results in an extensive increased demand for bone products supplying phosphoric acid or bone phosphate of lime. The constant trend of packing-house products is toward increased production of the dry-melter residue product called cracklings, causing a tonnage reduction in the production of the former standard feeding-meat residue known as digester tankage or meat meal.

CHAPTER XIII

PRODUCE AND OTHER SIDE LINES

The venture of the packing industry into the field of toilet specialties, peanut butter, and other delicatessen products, as well as butter, cheese, poultry, and eggs, is just as much a by-product phase of the industry, as the utilization of secondary parts of the animals slaughtered. In the latter case, the by-products are results of preserving and processing what would otherwise be wastes of raw materials and manufacture; while in the former case, the by-products are results of more complete utilization of the facilities of distribution. In the political criticism to which the packing industry has been subjected in the past there has been a tendency to refer to by-products of this type as the "unrelated lines of business" of the packer. Such a concept is not only short-sighted, but takes no account of the problems of efficiency in other fields of the industry than straight manufacture.

Mr. F. Edson White, president of Armour & Company, has said that "The problems of the packing industry do not lie so much in the management of the great plants, processing systems, and storage warehouses which are its visible evidences, as in the distribution and merchandising of the product. It is easy to buy livestock and to dress it, but it is a constantly recurring problem to find profitable outlets for meats, and to maintain or enlarge them." The reduction of the margin between producer and consumer, and the creation of new efficiencies, is equally the problem of the distributive system of the industry and of its processing phase.

Packers as Distributors of Dairy Products

It was, therefore, inevitable that in addition to the strict by-products of cattle, sheep, and hogs, national meat-packers should have become important agents in the distribution of dairy and

poultry products. Due to the fact that meat and produce require the same type of facilities for their distribution, the produce departments established by certain packers have expanded until they act as stabilizers for the business as a whole. During the past ten or fifteen years, probably the largest development in the commerce of agricultural commodities has been that in dairy and poultry products.

In their produce business, packers have utilized the principle of vertical integration through carrying on within their own organizations all middleman functions, and thus making more efficient the assembling and distributing of butter, cheese, eggs, and poultry. For example, certain packers own a considerable number of produce plants in the grain belt of the Middle West, where the best grades of butter, cheese, eggs, and poultry are produced, and where it is most economical to prepare these products for distribution. They carry on the actual marketing process through refrigerator cars and branch houses, by which all the perishable products of the packing business are vended. The advantages of national packers in the produce business lie, therefore, in plant locations, technical skill, research facilities, and steady outlets through their distribution systems.

This extension of packers into the field of distributing butter, cheese, eggs, and poultry began in a small way about 1900. Following this, some packers have become distributors of canned fruits and vegetables, which was logical, because of their previous experience in the canning and marketing of meats. Certain packers also handled cereals, grape juice, and other products, the ample justification of which is that these commodities are sold in largest volumes during the summer months, when trade in meat products is relatively light. By distribution of these side lines, better and more continuous use was made of sales organizations.

The facilities for handling these perishable products were already in existence, and it was natural for the packers to distribute them. Dairy products were sold largely to the same class of retailers which handled meats. For this reason, the same salesman could sell both lines, thereby decreasing his unit costs. Again, de-

liveries could be made in the same cars and wagons, and bills could be made out by the same accounting force. All this meant a better economic utilization of the packers' facilities. A more direct market was opened to producers, and a more direct source of supply was available to consumers.

Originally, packers entered the butter business and bought large quantities of butter from other manufacturers, but, more recently, became butter makers themselves through the establishment of their own creameries at many points in the Middle West. As a rule these creameries are located in the farming regions where dairying is a highly specialized occupation, as well as in districts where dairying may be less highly developed. For this reason medium-sized creameries perform a very important function in assembling butter fats, manufacturing butter, and in finding market outlets. By bringing the retail standards of these outlets back to the country the creameries have had an important influence in raising the quality of butter and other dairy products.

Since cheese, eggs, and poultry come normally from the same type of agriculture as butter, packers found that it was profitable to add to the functions performed by creameries. Therefore the handling of these products was combined with the original work of the creameries, resulting in the following advantages: (1) when the butter volume of trade is light the volume of poultry handled is heavy, thus reducing overhead expense to a minimum; (2) the same management is able to look after all of the different phases of the business; (3) the same refrigeration equipment can be used for all products; (4) the farmer finds it convenient to market cream and eggs together on the same trip to a produce plant.

The marketing advantages of packer-produce plants can be summarized by some examples as follows:

1. Intermediaries have been eliminated. Butter does not have to be shipped to a wholesale receiver, who, in turn, may reship it to a jobber in a neighboring city before it finally reaches the retailer.

2. The refrigerator car and branch-house system provide the shortest cuts in handling. Butter, cheese, eggs, and poultry are shipped to branch-house distributing houses, from which they are

sold direct to retailers by packer salesmen. Less than carload shipments can be employed readily. While it is possible to ship solid refrigerator carloads of produce, it is practical only to the largest markets where the bulk shipments are broken and smaller amounts in less than carload lots are sent on to small centers. The ability to ship produce in mixed cars provides fresh supplies continuously for markets not large enough to handle carload lots of a single product.

3. The whole system is managed from a nation-wide and a world-wide point of view from headquarters in Chicago. In this way equalized distribution is secured, and the price situation at glutted or undersupplied markets can be immediately relieved. All buying and selling operations are closely supervised from a single location, and specialized preparation of different products for various local markets is provided.

4. Packers are able to handle and advertise their dairy products in a national way. While other butter manufacturers have done this, the larger packers are particularly well qualified so to do with their national distributing organizations. They sell their individual brands in very large volume throughout the country, making for a standardization of quality, lower marketing costs, and a more extensive outlet for dairy producers.

The Poultry Business

The poultry industry is one of the large and important farm activities of the United States. In 1926, for example, there were produced eggs of an estimated value of $620,000,000, and poultry with a value of $561,000,000, making a total value for the poultry and egg crop in that year of $1,181,000,000. And these figures include only poultry production on farms, and not the production in cities and villages. In other words, the value of poultry products amounted to about 16 per cent of the total value of livestock and its products for 1926, being surpassed in this respect by only two other branches of the livestock industry: the dairy industry, with 40 per cent of the total, and the hog industry, with 22 per cent of the total.

The distribution of the poultry industry is country-wide, as poultry flocks are kept in every state and in every county. However, the greatest production occurs in the East North-Central and the West North-Central states, a region in which farm poultry flocks are predominant, and which accounts for 50 per cent of the total eggs produced in the country, and only slightly less than 50 per cent of the chickens raised. Iowa leads all other states in total chicken and egg production. Specialized egg farming is particularly important on the Pacific coast and in the northeastern states. Usually the value of eggs produced in the northern states exceeds the value of chickens raised, while in the southern states the value of chickens raised exceeds the value of eggs produced.

The poultry industry had its beginnings in the small flocks which were kept by the early settlers to produce chickens and eggs for their own use or for the use of their neighbors. As the population in general increased, and as the cities grew in size, there developed about them a local poultry industry designed to supply the needs of each locality. Because of the limited transportation facilities, however, the poultry industry continued local in character, although it showed a steady growth. For the most part flocks were small and there was little tendency toward specialized egg or poultry farms. This condition continued to a large extent, even with the opening up of western lands, until good railroad facilities became available, and particularly until about 1870–80, when the refrigerator car and cold storage were developed on a commercial scale.

Soon after these developments, wide new areas of production were opened for the supply of the eastern population, until production has reached its greatest volume in the middle-western states. Increase in the poultry population in the United States has proceeded steadily until, according to the 1925 census, there were 409,290,849 chickens on farms.

At the present time car-lot shipments of eggs and poultry destined for eastern markets average close to 1,000 miles of railroad haul. In late years there has developed a decided tendency toward the development of specialized egg farms to supply the

greatly increased number of urban dwellers. This tendency has certainly been stimulated by the development of artificial methods of hatching and brooding and by a better knowledge of housing management, and nutrition. In spite of this recent development, however, the production of eggs and poultry by relatively small farm flocks still accounts for most of the crop. This is due to the great number of such producing units scattered all over the United States. Probably more than 80 per cent of the total poultry crop is produced on general farms rather than on specialized poultry farms. The income from poultry on general farms plays an important part in the total farm income.

In recent years the tendency toward commercial egg farms has been very strong. This has been made possible through the development of artificial incubation, through the use of stove brooders which would accommodate large flocks of chicks at one time, through specialized breeding effort to increase the egg production of individual hens, and through the development of large commercial baby chick hatcheries. Investigations in the field of nutrition have also brought out important facts which have made it possible to keep layers under relative close confinement with good results. The principal areas of specialized egg farming are located on the Pacific coast, of which Petaluma is the outstanding example, and in certain areas along the Atlantic coast, such as the Vineland section of New Jersey. There is an increasing tendency also for general farmers to apply some of the methods employed on specialized egg farms and to carry larger flocks of layers than are characteristic of the general farm flock. Such flocks may properly be termed commercial farm flocks.

The development of the baby chick industry has had a great influence upon the poultry industry in the United States. This is a growth of recent years, as the extensive selling of baby chicks does not go back over a period of more than ten or fifteen years. At first the hatcheries were developed very largely to take care of a local demand for baby chicks. As it was discovered that chicks could be successfully shipped considerable distances, the size of the hatcheries increased until now there are some having a

capacity of upward of one million eggs. At first there was a decided tendency for this industry to concentrate in certain sections or states where eggs suitable for hatching purposes were more plentiful and more readily secured. The success of this industry led, however, to a wider distribution of the commercial hatcheries, until now the country is quite thoroughly dotted with them and their aggregate capacity approximates 200,000,000 eggs at one setting. At present there is a growing demand for better quality chicks than it has been easy to produce in these large capacity hatcheries.

As poultry production increased in volume and as it spread over a wider and wider territory there developed of necessity the business of collecting, transporting, and distributing these products in the areas of large population. This activity has now developed into a highly specialized business by means of which the eggs are gathered from producers, graded, and shipped to market under refrigeration. The poultry is gathered in a similar manner, often fed in feeding stations, slaughtered, and shipped to market in refrigerator cars.

A considerable live poultry business has developed also where the live poultry is shipped in specially constructed cars to markets where there is a large Jewish population which requires live poultry for its use. Some idea of the volume of this business, the consequent facilities required, and persons engaged both at shipping points and in distribution at the markets can be obtained from a statement of the receipts at the principal markets. In 1926, for example, there were received at New York, Chicago, Philadelphia, and Boston a total of 14,767,709 cases of eggs, each holding thirty dozen. In the same markets the receipts of dressed poultry amounted to 355,814,801 lb. At New York, the principal live poultry market, the receipts of this commodity amounted to about 12,000 cars, or approximately 200,000,000 lb.

Since both egg and poultry production are seasonal in character, the cold storage of these products has been developed to hold the surplus of the flush producing seasons for the period of relative scarcity. In recent years around ten million cases of eggs

have been held in storage at the height of the season, and well over 100,000,000 lb. of dressed poultry. In addition, from 50,000,000 to 100,000,000 lb. of eggs which are broken out of the shell and held in a frozen condition are also stored. The present trend is toward a leveling of seasonal production by securing greater egg production during the fall and winter months and by the production of early or winter broilers. Seasonal variation in production will never be eliminated, but eventually it may have sufficient influence to reduce somewhat the proportion of the yearly crop which must be carried in cold storage.

In recent years competition between those engaged in the concentration and shipping of poultry products and those engaged in their distribution in the markets has become keener and keener. This has led to some tendency toward consolidation of small individual packing plants into larger units. It has also been one of the factors leading to improvements in the marketing process designed to secure greater efficiency. For example, improved packing materials for the egg cases and improved methods of loading and bracing the eggs in the cars have reduced the loss during transit through breakage. There have also been improvements in the storage of eggs, principally in the use of odorless packing materials to eliminate development of the typical cold storage taste, and the holding of eggs under carefully controlled conditions at higher humidities, thus reducing the evaporation which normally takes place during the storage period.

One of the important developments in marketing poultry products of more recent origin than the entry of the packers into this marketing field has been the formation of co-operative marketing organizations. The most outstanding examples of this are the co-operatives on the Pacific coast which maintain a federated selling agency in New York City for the distribution of Pacific coast eggs in the eastern United States, and co-operative marketing associations in Missouri, Minnesota, Ohio, and elsewhere. At the present time a large volume of business is carried on by these co-operative organizations. For example, in 1926, sixty co-operative associations handled 3,150,000 cases of eggs valued at $29,-

900,000, and thirty-one associations handled 17,000,000 lb. of poultry.

Competition with the domestic product has not been serious in the case of shell eggs of foreign production. Our exports of shell eggs during recent years, while moderate in volume, have exceeded imports. There is a different story, however, with reference to the importations of frozen and dried eggs. Very considerable quantities of these are imported, mostly from China, and they constitute an important source of competition with the domestic product. In fact, dried eggs are imported from China and sold at a figure which has almost entirely prevented the development of a dried egg industry in this country.

An important forward step in the poultry industry of the United States has been the development of systematic breeding on the part of large numbers of poultry keepers who are interested in improving the efficiency of production of their stock. Obviously, the more efficient the producing ability of stock, the better the opportunity for profit, and this has been the great incentive toward this end. Undoubtedly the development of trap nesting, which made possible a record of the production of individual hens, has been a most important factor in improvement of breeding stock. The large number of laying contests conducted throughout the United States has also tended to concentrate attention on this matter of better breeding.

In the next few years there will undoubtedly occur a considerable development along the lines of record of performance work throughout the United States. Already a number of states have such work in operation, which consists of state supervision of performance records on owners' farms, and the establishment of official records for the individual birds and flocks. This demand for better breeding stock is also seen in the desire for a better quality of baby chicks. Individual states are attempting to meet this situation by the development of accreditation and certification for baby chicks and baby chick hatcheries. This plan simply means that the eggs used for the production of baby chicks come from flocks which have been inspected as to their general health, qual-

ity, and producing ability. The further development of this plan is the production of baby chicks from eggs produced by flocks which are free from certain troublesome poultry diseases, such as bacillary white diarrhea and tuberculosis.

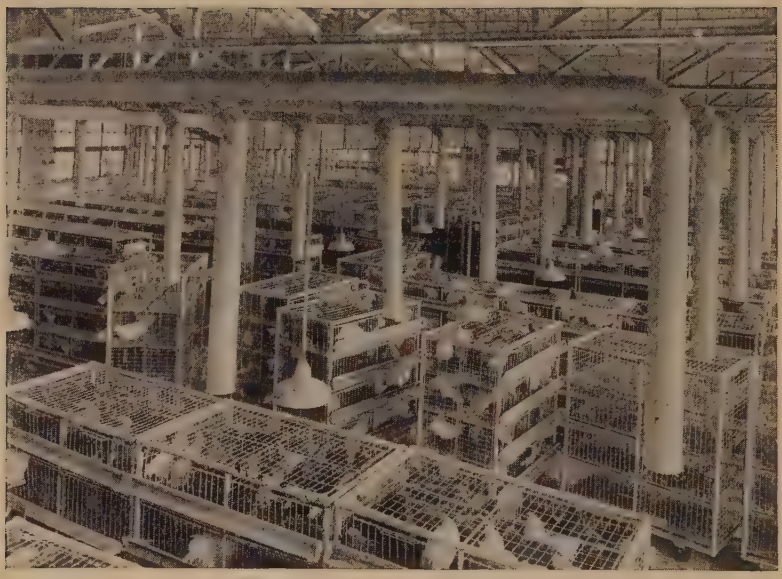
In handling poultry there are certain special advantages due to the functions performed by packers, which are briefly these: (1) they collect the live poultry produced in surrounding territories, (2) they sort the mixed receipts and weigh according to kind, after which the poultry is placed in feeding batteries for conditioning; (3) the poultry is then killed, dressed, cooled, and graded for quality, kind, and size; (4) the dressed poultry is then placed in cooler or freezer pending shipment.

Classification of Breeds

In recent years there has been considerable specialization in poultry production, with careful selection for the purpose of meeting each definite market need. The breeds which are of the greatest commercial importance can be divided into four classes: (1) The Mediterranean class, in which development has been for egg production. (2) The American class, which includes breeds that have been developed for both eggs and meat, such as Plymouth Rocks, Rhode Island Reds, and Wyandottes. (3) The English class, which is for dual purpose, but which is more valuable for meat than the preceding class. It includes Orpingtons, Dorkings, as well as Cornish Indian game, which is purely a meat bird. (4) The Asiatic class, which is heavier than the other classes, less regular layers, more broody, and specialized more definitely for meat.

The breeds best adapted to the particular types of market poultry demanded are indicated as follows:

Type of Market Poultry	Sorts of Breeds Adapted
Squab broilers	Leghorns, Anconas
Heavy broilers, fryers, and roasters	Wyandottes, Plymouth Rocks, Rhode Island Reds, Orpingtons
Mature fowls	Plymouth Rocks, Orpingtons, Cornish, Wyandottes, Rhode Island Reds
Capons	Brahmas, Orpingtons, Cornish Black Giants, Plymouth Rocks



FEEDING BATTERIES IN POULTRY PLANT

PLUCKING AND DRESSING POULTRY

For all poultry breeds the main purpose is to develop proper quality of meat for satisfying the trade demand. There are, naturally, variations from breed to breed. Another factor in determining quality is size, e.g., large broilers, fryers, and roasters are desired for certain trade demands, while under other conditions small broilers are preferred. Small and medium-sized fowls are usually preferred for the dressed poultry trade, but there is a good demand for the larger sizes in the poultry market. Shape is a factor of significance, and ordinarily all trade outlets desire a well-fleshed compact body, with relatively short legs and wings. Poultry showing small dressing loss is preferred. The average percentage of waste and inedible parts of the four main breeds, namely, White Wyandotte, White Leghorn, Light Brahma, Barred Rock, is as follows: Fowl, $10\frac{1}{2}$–11 per cent; chickens, $10\frac{1}{2}$–13 per cent. Other factors in dressed poultry marketing are color of skin, texture of flesh, and flavor.

The main sources of supply for a centralized produce plant advantageously situated in a producing territory are as follows: (1) from the farmers who bring in their own poultry to the plant; (2) express and motor-truck shipments from buying stations, which may be operated by the centralized plant or owned by an agent buying on a commission basis. Because it is necessary for the packer-produce plant to distribute a uniform type of poultry, it has been found desirable to operate feeding stations, in which all poultry is fattened under very carefully controlled conditions in preparation for market. In addition to adding weight in flesh and fat, this process improves the quality of the meat. Fattening birds under strict confinement results in more moisture in the flesh, and the lack of exercise softens the muscle part of the meat, making it more desirable for the average consumer. Feeding stations operated by packers are usually well-built structures. The sanitary conditions under which poultry is milk fed and handled include plenty of light, good circulation of air, and absolute quiet to prevent the birds from becoming excited and not digesting their feed to the best advantage.

Killing, Picking, Chilling, Grading, and Drawing Poultry

In the operation of a packer poultry plant the killing, picking, chilling, and drawing are important factors in turning out uniform quality products. In order to obtain a well-bred and attractive carcass free from feathers, bruises, tears, and other blemishes, poultry must be correctly killed and dressed. This is best performed by severing arteries in the throat for bleeding purposes and "sticking" to paralyze the brain, thus enabling the feathers to be pulled out easily without dipping in hot water. While formerly poultry were usually picked by scalding, it is common practice at present to dry pick them, if they are not to be eaten at once. This dry picking has in part been made desirable by the development of producing areas at a great distance from the market. As soon as possible after killing, poultry is chilled to remove animal heat, for if this is not done, bacteria develop which injure the flavor and appearance of the bird. Chilling may be carried on either by a wet or dry method, the relative merits of which are somewhat in controversy. While the chilling is going on, the poultry is on cooling racks especially prepared for this purpose. Since a well-prepared, dressed bird is most desirable for shipping and marketing, it is not usually drawn until just before delivery to a customer.

In grading dressed poultry attention is given to age, sex, weight, toughness of flesh, color of skin, method of fattening, shape, etc. In the plant, temperature and light are carefully considered so there will be proper conditions for grading accurately and uniformly, since it is more difficult to grade poultry than eggs. Both grading and packing of poultry are closely supervised, for the average number of employees in a good-sized poultry plant is between sixty and one hundred people during the busy season.

Definition of Fresh Killed Dressed Poultry

Poultry is graded according to its classification, quality, and weight. The various grades are usually defined as follows:

Broiler.—A young bird of either sex, soft meated and tender as indicated by: (1) tip of breast bone is flexible; (2) tendons in legs pliable; (3) legs free from spurs and the skin a bright color, a bloom; (4) skin on body clear, almost transparent, and uniform in color; (5) bird's weight not over $2\frac{1}{2}$ lb.

Roaster.—An immature male bird which shows the same desirable characteristics as broilers and dryers, but not to the same degree. Such birds sometimes show "buttons," or the beginning of spurs. Roasters run over $3\frac{1}{2}$ lb. in weight.

Stag.—A male bird of any weight, usually from 2 lb. up, approaching maturity, yet not old enough to be classed as a rooster. It usually shows well-developed buttons, possibly spurs, and is bluish over legs and hips, indicating that meat is becoming hard. The breast bone shows firmness.

Fowl.—A mature female bird. Breast bone becomes firmer, and body is plump.

Capon.—An unsexed male bird, distinguished from a rooster by the undeveloped spurs, comb, and wattles, and by the formation of head and body. Its weight runs from 6 lb. up.

Capon roasts or slips.—Birds which have been unsuccessfully caponized, with body formation resembling that of a roasting chicken. It shows greater head development than a capon, and does not carry its fat weight.

Turkeys.—Hen turkeys may be either mature or immature female turkeys. They usually weigh 7 lb. and up. Young Toms are immature male stock, usually weighing 10 lb. and up. Old Toms are mature male turkeys weighing from 16 lb. up. Age in turkeys is indicated by the same characteristics as in chickens: by tip of breast bone, skin color, and leg tendons.

Western ducks.—Western ducks are range fed, and, like range-fed chickens, show characteristic yellow skin. They are generally marketed at eight months and come in any weight, though they usually run 3 lb. and up.

Western geese.—With the exception that western geese generally weigh 8 lb. and over, they may be defined in the same terms as western ducks.

Long Island ducklings.—Milk-fed, 5 lb. and upward, Long Island ducklings are famous for tender meat and fine flavor, distinguished from western ducks by larger size, and bleached, white color, characteristic of all milk-fed poultry.

Squabs.—A pigeon which has never flown, specially fed, and selected for fulness of breast, tenderness of meat, covering of fat, and dressing qualifications, with choicest weights ranging from 9 lb. per dozen up.

Pigeons.—Matured squabs, not showing covering of fat or fulness of breast as in squabs. Pigeons are generally marketed full feathered; of any weight, but generally 12 lb. to the dozen.

Guineas.—In the guinea class, spring or broiler guineas correspond to broilers and fryers in the chicken class, of 1–2½ lb. in weight. Some stock is marketed full feathered and unbled. Other stock is fully plucked and bled, and used as a game substitute because of its gamey flavor and dark meat. Old guineas and matured guineas are always marketed full feathered and unbled, and are distinguished from broiler guineas by their size and by their development of body and comb.

Packing and Shipping Poultry

The final operation in the normal process of actually preparing dressed poultry for market is that of packing. Better grades of poultry are packed twelve birds to the box, which is usually made of odorless lumber. Fowls are not packed or wrapped separately, but the box is lined with parchment paper. As a rule, young birds are wrapped individually, and are packed both in breast-up and side-pack style. The reason for freezing in packing is due mainly to the fact that young chickens move from farms to feeding stations during the late fall and early winter months. Until box-packed poultry is received by the consumer and eaten, it should always be held very carefully at a temperature of 25°–30° F. If kept more than a few days it is held at about 15° F. in cold storage, and then in a sharp freezer at about 0°–5° below, to avoid impairing the appearance and quality.

After poultry has been boxed in the packing plant it is shipped to branch houses, or to other buyers, in refrigerator cars. In certain cases dressed poultry is shipped in carload lots, but more often in less than carload lots, and in all cases and at all seasons dressed poultry requires special refrigerator cars. Mixed shipments of dry-packed eggs and dressed poultry are often made. Stock cars are thoroughly pre-cooled before being loaded, and curtains are usually placed in the door to prevent entrance of heat while the cars are being loaded.

In country produce plants, after poultry has been properly milk fed, dressed, graded, packed, and chilled for shipment, it is turned over to the packer for distribution. The greater part of the larger packers' production is shipped direct to important eastern branch houses on a weekly standing-order basis. These houses develop trade demand for all the different sizes and grades of poultry which move during the changing seasons of the year. They accept shipments in the natural proportion of grades and sizes, or, in other words, in an assortment of the same proportions as it is graded on the cooling racks. Some of the outlets cannot handle straight cars, and to reach them with a supply of poultry the packers ship joint cars, or ship to some centrally located warehouse for distribution to the car routes and smaller branch houses.

From 75 to 80 per cent of the poultry handled by meat packers is marketed in the east, particularly in Boston, New York, Philadelphia, and the surrounding territory. Broilers are largely consumed by hotels and restaurants. The bulk of the frying chickens is sold in this country, but considerable stocks are exported to England. Roasting chickens are consumed by all classes of trade, but particularly in the eastern and southern resorts. The fowl are consumed likewise by all classes of people, and outlets for fowl and chickens include the following: butchers, public markets, city clubs, country clubs, roadhouses, steamships, lodges, manufacturing-plant restaurants, ship chandlers, hospitals, institutions, commissary buyers for mine, lumber, or oil interests, grading camps, chain stores, and grocers.

Seasonal Marketing of Poultry

The poultry-packing season usually begins in July and lasts until the first of January, but most of the broilers are accumulated and stored during July, August, and September. The usual season for storing frying chickens is during September, October, and November, while the year's supply of roasting chickens and fowl is accumulated during October, November, and December, with the heaviest receipts in late November or December. These seasons are longer and are not as clearly defined as the seasons for strawberries and vegetables. They are sufficiently marked, however, that, during the egg season, the whole force at a packing plant is employed at packing eggs. The transition from the egg season to the poultry season is somewhat gradual, but in October, November, and December the whole force is busy packing poultry. Ninety-five per cent of the turkeys are killed, dressed, and marketed during November and December. About 75 per cent of all the turkeys consumed in the United States are sold for the Thanksgiving and Christmas trade. The Thanksgiving turkeys are usually not fully grown or fat, and the extra month's feed gives them a much better finish. They can then be successfully frozen, and thaw out bright and clear. This freezer stock is used almost exclusively by hotel and resort trade, most of the larger hotels having turkey on their menus the year around.

While the relation of actual prices to grades in any example can only be an approximation, the ratio in the following illustration will indicate in a general way how grades affect differences in price. If poultry costs 18 cents a pound alive, delivered at the packing plant, and the expense of preparing it for market runs about 7 cents a pound, a price of 25 cents a pound is incurred for unpacked poultry ready for delivery. An average price of 25 cents requires for the first grade about 30 cents; for the second grade, around 27 cents; and for the third, around 23 cents; with the fourth grade bringing about 15 cents. At times, however, some grades and classes will be out of line, due to temporary, accidental, or local conditions. The percentage of different grades of dressed poultry coming out of an average car of live poultry varies with particu-

lar packers. Some houses set a very high standard for the first grade, and therefore find less than 50 per cent first grades, 25 per cent second, 15 per cent third, and 5 per cent fourth grades and "rejects" (birds unfit for consumption are burned).

Poultry By-Products

By-products of the poultry industry have considerable value. Of these feathers and fertilizer are the most important. Feeding-station waste, e.g., dead birds, blood-spoiled feathers and manure, has fertilizer value. From a practical merchandising point of view, the disposition of poultry fertilizer is a difficult problem, since this fertilizer is not as important in the trade as it used to be. On the other hand, feathers have extensive uses, especially in the manufacture of millinery specialties and in the making of pillows, cushions, mattresses, dusters, and artificial flowers. The value of feathers is affected by the class of birds producing them and by the color.

Goose and duck feathers are usually more valuable than chicken and turkey feathers, and white feathers always command a higher price than colored ones. The value of feathers obtained when dressing poultry is sufficient to defray much of the packing-plant expense. Various qualities of feathers, such as body, tail, wing, white, colored, dry-picked, scalded, clean, dirty, etc., are kept separate in order to be sold to the best advantage. Various kinds of feather-drying apparatus have been tried, but they do not seem to remove the odor properly, and most packing-houses have returned to the original method of storing the feathers in large, well-ventilated rooms, stirring them daily, and depending on the air to dry and deodorize them. The feathers are transferred promptly from the killing room to the drying room. In many instances this transfer is made by means of suction pipes which connect with the boxes or troughs in which the feathers are thrown by the pickers. If the feathers are on the floor, they are cleaned up at intervals during the day or night by suction pipes suspended from the ceiling or connected with a trap door in the floor. After being thoroughly dried, the quill feathers are packed straight in

boxes, and the body feathers sacked and held until a carload has accumulated. They are sold to feather companies, who renovate them with steam, making them available for use in manufacturing pillows and other bedding, millinery supplies, boas, and dusters.

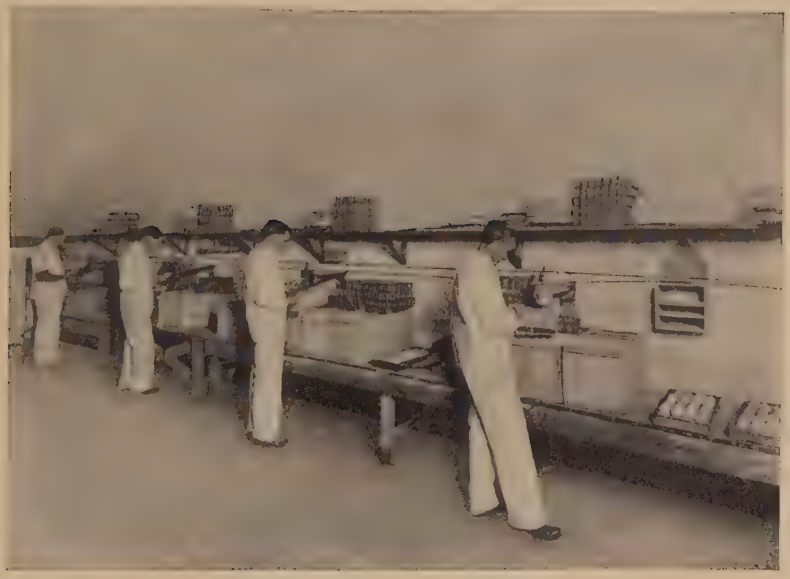
The Egg Business

Eggs have always been an important food product, though in recent years they have tended to be somewhat more widely used. To meet the demands of a denser population and large city markets, it was natural that the preparation and distribution of eggs should be put on a more scientific basis. While eggs are produced in every state in the Union, more than one-half of those entering into interstate commerce, i.e., marketed on the five central markets, are produced and shipped from the five following states, in order of production: Illinois, Iowa, Missouri, Indiana, and California. The producers of eggs in each state have a choice of markets, but the amount which goes to any particular market depends largely on economic conditions. For example, Illinois egg distributors ship 90 per cent to eastern markets and only about 10 per cent to Chicago. On the other hand, Iowa sends 40 per cent of her egg production to Chicago and 60 per cent to New York.

The problems of the meat packer in the egg business are not those of a manufacturer, but of a distributor, although he carries on a large-scale production of eggs by modern scientific methods. In preparing eggs for the markets it is necessary to obtain a quality and uniformity which will meet the demands of the consumer in all parts of the country, and to ship them in such shape that they will reach him in good condition. The grading, packing, storing, and marketing of eggs involves a highly specialized organization which is required for its perfection. Some of these functions and the methods employed to carry them out will be described briefly.

One of the most important operations in a produce plant is proper grading. Grading requires a knowledge of conditions influencing quality, as well as the separation of the eggs into various lots, based on external and internal factors. Quality in eggs is de-

ONE METHOD OF PACKING DRESSED POULTRY



EGG CANDLING

termined in the plant by a process of inspection known as candling, which consists in passing the egg before a bright light and in observing imperfections by means of the light transmitted. Candling is the best commercial method of determining the interior quality of eggs. In considering eggs for market need, the interior quality is ordinarily of greater importance than the exterior. Care must be taken to hold the temperature at the best possible point for preservation.

Grading Eggs

Even with the process of candling, the practical grading of eggs is quite complicated. No two eggs are ever exactly alike. However, candling, when carried on by experienced workmen, results in a uniformity of grading which is well adapted to the needs of the trade. While the exact relative importance of these qualities varies according to the particular use to be made of the different grades, the usual factors which are in the mind of the candler are: (1) interior quality, which includes condition of yolk, air cell, and white; and (2) exterior quality, which includes soundness of shell, cleanliness, size, color, and shape.

The principle involved in most egg-grading rules is to require a certain percentage of fine eggs in a grade, rather than to describe a quality which all the eggs to be included in that grade must equal. The grading of eggs for the wholesale trade, in order to be conveniently used, must be applicable to the lots of eggs just as they arrive on the market from shippers. These may include current receipts, rehandled current receipts, graded eggs, or undergrades. Human judgment is a great factor in this. To standardize egg grading, colored egg-candling charts have been prepared by the United States Department of Agriculture.

Chicago being the greatest egg market in the country, the grades established on that market are of prime importance. They are for the most part self-explanatory, and are as follows: (1) fresh gathered, (2) storage packed, and (3) refrigerator. Fresh gathered eggs are divided into three grades, viz., extras, firsts, and ordinary firsts. Egg grades are elastic because of unavoidable seasonal changes in quality. For example, the eggs which come to

market during the summer and autumn are not equal to those arriving in the spring. As this situation begins to make itself felt, grading requirements are lowered accordingly. When the quality begins to improve, however, standards are advanced. In other words, the best eggs which come to market in August are somewhat inferior to the best of those arriving in March, and egg merchants all over the United States adjust their candling and grading requirements with this fact in view.

In distributing eggs, the packer has to keep carefully in mind the generally accepted market definitions. And such distinctions between eggs are known also in a general way to consumers. For instance, a genuine fresh or new-laid egg is strong bodied if it will stand up well when broken out on a plate, and is sweet and unclouded. Such characteristics can be seen by holding the eggs before a strong light, as in candling. Genuine fresh eggs until recent years were considered to be those laid within a short season, for the most part in the spring. However, the commercial methods applied to egg production and distribution have resulted in a condition where there is an approach to all-year production, with the storage season becoming shorter year by year. Usually, genuine fresh eggs are not more than 72 hours on the road from the nest to the consumer. However, it can be readily seen that since eggs are produced at points which are distant from the centers of consumption, it is impossible to market the great majority of them within the 72-hour period. Indeed, most fresh eggs marketed are semifresh, known as commercial or western fresh eggs. The eating quality of these eggs is good and they meet all requirements of the trade; but, naturally, they do not show up in a scientific test quite as favorably as genuine fresh eggs. For example, they may be somewhat cloudy, have a little larger air space, and stand up less well when broken.

Three other definitions of eggs are clearly understood and employed in the trade; namely, refrigerator, storage, and processed eggs. Refrigerator, or cold-storage eggs are generally defined as eggs that have been held in a cold-storage warehouse for thirty days or longer, at an artificial temperature of 45° F. or less. As a

general rule, storage eggs are superior to commercial fresh eggs from the beginning of hot weather until the first of January. During extremely warm weather, fresh eggs are subject to deterioration all the way from the nest to the table. As a result, they usually come to market in weak and watery condition. The storage eggs marketed during the hot weather are gathered when production was flush, are brought to market when outside temperatures are most favorable to transport, and are placed in storage where their fresh qualities are preserved. Processed eggs are those that have been specially treated, usually for the purpose of preservation, by some operation affecting the condition of the shell. Commonly this is effected by spraying or dipping in various solutions, such as waterglass. Storage eggs are those which have been packed in a manner suitable for refrigeration and warehousing. In preparing them the usual method is to sort out checks, small eggs, and dirties, and to place the No. 1 eggs in new cases.

Marketing of Eggs

While eggs are sold in every village in the United States, there are five primary markets to which reference has been made, viz., New York, Chicago, Boston, Philadelphia, and San Francisco. New York receives 40 per cent of the total amount of eggs at these markets, with Chicago second. Chicago's big receipts are due to its location in the center of poultry production and cold-storage facilities, as well as to its large population. New York has not only a big population, but adjoins territory containing a much larger population. New York receipts are largely from the Central West, and eggs reaching it must travel a greater distance than those reaching Chicago. The natural result is reflected in the prices of these two markets. The average price for a series of years in the New York market is usually three or four cents a dozen over Chicago prices.

The national packers, who are distributors of eggs, use as their outlets their branch-house and car-route systems, and have a direct and speedier method of marketing than is the case with producers who ship to large central markets from which the commod-

ity is distributed again to the final consumer. In shipping eggs from plants to branches it has been found that the best type of wholesale egg package is the thirty-dozen case, which is cheap, very strong, yet light in weight, and can be stowed in refrigerator cars with maximum efficiency and convenience in handling. This thirty-dozen case is the standard wholesale case in the egg trade of the United States. However, for retail distribution there is a great variety of packages, e.g., parcel post packages and cartons. Of the cartons, that which is arranged to hold six eggs in length and two in width is in most favor.

Egg prices are naturally influenced by variations in demand, due partly to industrial conditions and population changes. While eggs constitute a stable food whose use is fairly constant throughout the year, there are violent fluctuations in prices from time to time, for the intensity of demand for eggs is quickly increased or diminished by the available supply, which, in turn, is reflected in egg prices. These changes in egg prices are influenced also by the fact that the supply of eggs is irregular. For example, during April, May, June, and July, many more eggs are marketed than consumers can use. In winter, consumption is much greater than supply, and storage eggs are used. The same conditions apply to poultry, both live and dressed. Some conditions that influence prices are temporary, and others are permanent, e.g., if the weather is unusually cold during the spring when egg production should be heavy, the effect is higher prices, not only in the spring, but for the remainder of the summer and the following winter. Available supply of eggs is affected by such influences as weather, storage, changes in prices, imports, supply of refrigerator cars available to shipping territory, interference with railroad traffic, terminal market receipts, and trading stocks. Of these the weather and storage stocks are the most important.

The heaviest egg receipts are in April. During the months of heaviest receipts, prices are low. For example, receipts almost always increase during February and cause a drop in prices. Prices often fluctuate during the winter because of cold weather, which prevents normal egg laying. However, winter fluctuations are gen-

erally less marked than those in summer, as storage eggs are available to fill deficits. The egg-price year is divided as follows: the summer low, characterized by heavy supplies, and during which time the refrigerators are filled; the fall rise, marked by decreasing supplies and drawing upon refrigerator stocks; and the spring decline, marked by an increasing supply and falling prices.

There is a continuous interaction between the supply of, and demand for, eggs. This is shown in the relation between country

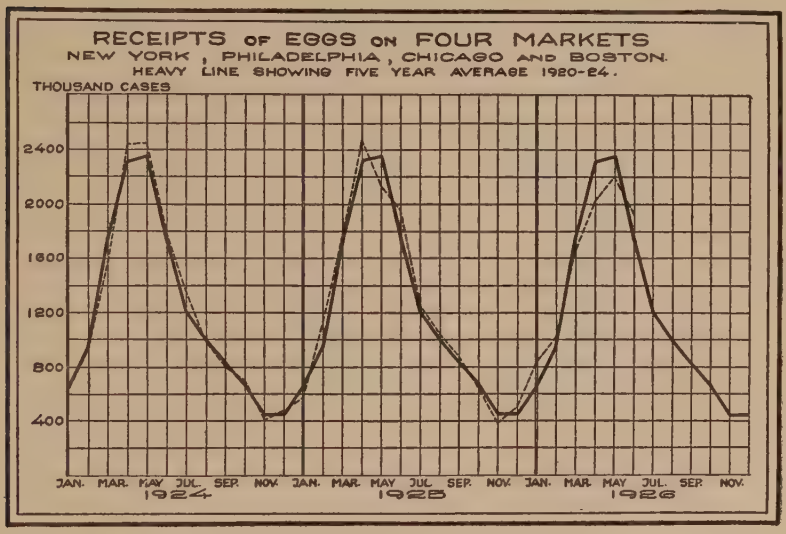


FIG. 50

and city prices. For example, a decrease in New York egg consumption affects retailers, whose demand immediately decreases. Jobbers, shippers, country stores and producers feel this decreased consumption in turn. Such price influence may, however, begin at any point and spread to the other factors in the trade. In practical trading, the operators and distributors are guided by immediately available current statistics, which bear on a great number of different factors, some of which may be noted as follows: production, quality and wastage of the product, transportation facilities, government regulation of the trade, consumer demand,

prices of substitutes, prospects of strikes in the country or city, receipts in the important markets, storage holdings and weather reports indicating effects on the quality of the product, shipping, transportation, and handling in the markets.

In general, New York City represents consumers, and Chicago shippers. Therefore, in establishing market values New York usually reflects the pessimistic attitude of buyers, while Chicago represents the optimistic attitude of sellers. Both New York and Chicago have large warehouse facilities in case of a glut. At such times either of these cities may assume the rôle of the consumer, in the sense that the products may be removed from the visible supply when necessary. On this account there is a continuous series of cyclic changes in storage supplies going on between New York and Chicago. When the New York price level is higher, shipments are diverted from Chicago to the East; when the Chicago price is higher, they are diverted in the other direction. Since New York reflects the ultimate consuming disposition, most of the contracts made in the United States, whether in Boston, Kansas City, San Francisco, or New Orleans, are based on the New York rather than on the Chicago quotations.

There remain to be mentioned certain miscellaneous egg products of importance, e.g., waste matter, eggs for hatching, and day-old chickens. Spoiled eggs are sent to plants in large distributing centers, where they are manufactured into commercial products. For example, a commercial liquor for tanning leather is made from the yolks, and a commercial albumen for various uses, such as photographic plates and films, and dye materials, from the whites. Such plants make use of all "rots" in which the yolk and white can be separated. The refuse from chicken hatcheries is used for fertilizer by some operators.

The Butter Business

Of the dairy products distributed by meat packers, butter is the most important. This is natural because among manufactured dairy products butter is the leader from the point of view of consumption. The growth of the butter business of certain packers

was undoubtedly stimulated by the fact that Anglo-Saxon countries are among the largest consumers of butter. With the biggest population among English-speaking peoples, the United States shows a larger total consumption of butter within its boundaries than any other important nation. True, in per capita butter consumption the United States is exceeded by Great Britain and one or two other countries. However, in this country the demand for butter is growing, and each year sees an increase in the amount produced and distributed.

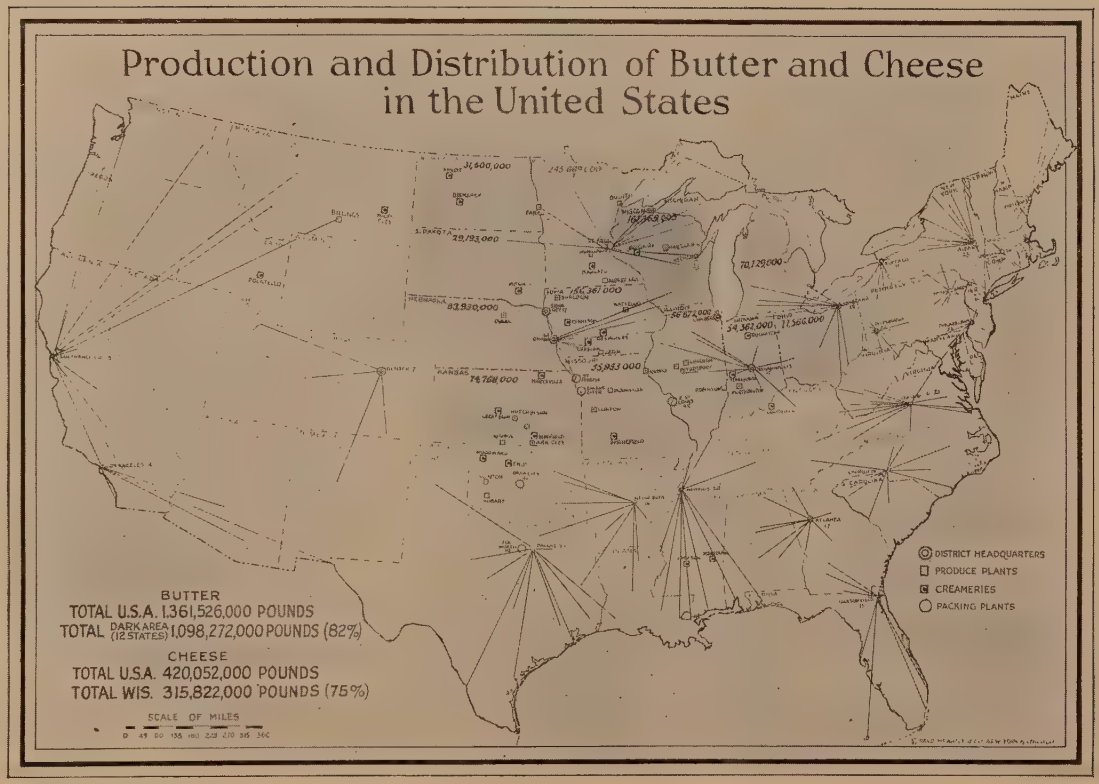
From a trade point of view there are two general classifications of butter, viz., farm and creamery. At the present time there is approximately twice as much butter made in creameries as on farms, and the proportion of creamery butter is increasing yearly. This latter type of butter packers distribute on a national scale. The economic reasons for this growth of creamery butter in domestic and foreign commerce, and the decline in farm-made butter, are based on the ability of the farmer to sell his raw material in the shape of cream (due to improved transportation conditions, especially good roads and automobiles), the better prices now realized for cream as compared to farm-made butter, and finally, a wider geographical distribution of creameries. Of these factors by far the most important is the second, for as the farmer became aware of the fact that he could realize more money for his cream output than he could for farm-made butter of variable quality, there has been a corresponding development in the manufacture of creamery butter.

In 1925 the total amount of butter produced in the United States was estimated at 1,361,526,000 lb., of which creamery butter was by far the largest part. Most American butter is manufactured in the North-Central states. In other sections of the country, only a little more than one-ninth is produced in the Pacific and Mountain states, and a little less than one-ninth in the Atlantic states. The North-Central states, where creamery butter is produced in heaviest volume, include Minnesota, Wisconsin, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas; while the other North-Central states rank closely behind those

mentioned, and include Ohio, Indiana, Illinois, and Michigan. The production situation for butter is similar in a general way to that of livestock, for the majority of the population of the country lives to the east of the main producing region in the Middle West. Thus, butter distribution, like livestock distribution, consists largely in shipping the commodity eastward from the Middle West to the main consumption centers.

Modern commercial manufacture of butter is a recent development. Indeed, it had been systematized on this basis only a decade or so before meat packers began to add butter to the list of products which they distributed in interstate trade. Until 1890, most commercial creameries bought whole milk from producers living in their vicinity, and performed the work of skimming and of churning in the creameries themselves. With the introduction into creameries, skimming stations, and farms of the centrifugal separator, the old-time whole-milk creamery system for butter production was superseded by a factory system receiving cream only. The significance of this evolution of the butter industry was that it became possible to separate the milk on farms and ship the butter fat. In this new method the advantage was that cream does not deteriorate in quality as quickly as milk. With this development, the centralized creamery, to which cream could be shipped from relatively long distances, came into existence, and changed the method of procuring raw material from one by which large amounts were handled to one in which the raw materials were transported in relatively small amounts. Consequently, individual creameries were able to draw their supplies from an ever widening territory.

Meat packers were already engaged in the dressing of poultry at country points and had established plants at strategic market centers. It was natural that, with the development of centralized creameries, the plants already established by packers should also be utilized as churning points for cream. Furthermore, there was an added economic advantage in that the by-product of a creamery, buttermilk, is necessary for the proper feeding of poultry, and, when produced in the same plant, would cut production


Production and Distribution of Butter and Cheese in the United States
BUTTER
TOTAL U.S.A. 1,361,526,000 POUNDS
TOTAL DARK AREA (12 STATES) 1,098,272,000 POUNDS (82%)
CHEESE
TOTAL U.S.A. 420,052,000 POUNDS
TOTAL WIS. 315,822,000 POUNDS (75%)
SCALE OF MILES
DISTRICT HEADQUARTERS
PRODUCE PLANTS
CREAMERIES
PACKING PLANTS

costs. The packer-produce plants, therefore, enlarged their functions in the interests of efficient distribution.

Changes in Butter Distribution

The growth of butter marketing by meat packers followed closely upon the establishment of the predominant position of centralized creameries. Originally, the small whole-milk creameries in Iowa, Wisconsin, and Minnesota faced only a manufacturing problem. Distribution was an economic function delegated to commission merchants on the primary markets, which included a few very large cities of the country. However, the advent of the centralized creameries revolutionized the marketing system. Because of the uneven quality of the raw material coming to them, the centralizers were forced to choose between purchasing the raw material at lower prices than a whole-milk plant, or selling the product to better advantage. The first alternative was, of course, out of the question. It was necessary, then, to effect a more efficient sales method, and the meat packers naturally led, through the utilization of their refrigerator car and branch-house system, and their pre-existing sales force. As time went on the large volume of business enabled them to cut directly across the traditional marketing route and sell more directly to the consumer. In other words, these centralized creameries were able to eliminate the services of two or more middlemen by performing these functions themselves. It was this more efficient distribution which enabled the centralized creameries to develop a nation-wide trade in butter.

This direct movement to the retailer began in the nineties and was initiated by a policy of studying consumers' taste and meeting it. It was found that consumers wanted butter that was uniform in flavor, color, and salt, of good keeping quality, and put up in conveniently sized packages. The consumer also required that the package be such as would preserve not only the goodness of the butter, but also protect it from contamination in handling. The industry set out to comply with these demands and to develop a market for its product by placing on its books weekly standing

orders. This plan met favor with retailers and marked a revision in the supply and trading in butter, until by gradual development the majority of retailers now buy, year after year, from the same creamery. Furthermore, the customers of these retailers are, year in and year out, using butter made by the same methods in the same creamery.

The result has been that creameries have extended their churning plants more widely, in order that the volume of their manufacture may keep pace with the increasing demands, and now often require express or baggage-car service on more than 90 per cent of the cream received. Most of such creameries establish cream-receiving stations at country towns. The common location of centralized creameries is in large cities, such as Chicago, St. Paul, Omaha, and Denver, or at railroad junction points having several branch connections. Such locations afford not only entry to a large territory from which to draw supplies of cream, but also give access to a large local outlet for the products of this cream. To such plants the raw cream is shipped from considerable distances, often 500 miles. For example, creameries in St. Paul draw on North Dakota, and points even farther away.

The creameries belonging to packers market butter in large quantities in almost every big city. This marketing may be done through branch houses or by direct shipment from the plant. The most natural outlet in the meat-packer system of marketing butter is through the branch-house organization. By this method the usual time elapsing between collection of the raw cream at the plant and delivery of butter to the branch house is approximately ten days. Shipments are made at frequent intervals, and branches order in quantities only sufficient for current needs between shipments. As a result, the local branch-house stock of butter is always in fresh condition and prices are maintained at replacement values. This system is in contrast to methods of distribution employed by the competitors of the packers, who ship the bulk of their butter in tubs to the large markets. There, after passing through the hands of one or more middlemen, it is reshipped to points of consumption, either in its original tubs or

after being cut into prints. Butter handled in this fashion is frequently five weeks en route from farm to consumer.

The principal customers to whom branch houses sell their product are: For print butter: groceries, meat markets, delicatessens, candy manufacturers, bakers, hotels, restaurants, public institutions, clubs, road houses, dining cars, and steamships. For tub butter: groceries, meat markets, candy manufacturers, soup manufacturers, hotels (for cooking), clubs (for cooking), institutions, and bakers.

Factors in Butter Making

To meet the ever increasing demand for butter, creameries have developed the various technical phases of butter making as the result of the experience of their staffs of experts. After procuring cream, either directly from farmers or indirectly through cream-buying stations, the cream is graded for quality by taste and smell, and the producer is paid on a butter-fat-content basis, which is arrived at by an analysis of representative samples. The next step is the weighing of the cream, after which it is dumped into a glass-lined vat and prepared for pasteurization. Due to the variety of sources of the cream, one of the important steps in manufacture is the neutralization of excess acidity, and the absorption of the different flavors dependent upon the individual sources. Pasteurization follows, a process whereby the cream is heated momentarily to a temperature of 180° F. for the purpose of destroying bacteria and improving keeping qualities. It is then rapidly cooled and ripened to develop the desired flavor, following which it is placed in churns having a capacity of about 1,000 lb. of butter. Churning of the cream at standard temperatures now takes place, and after about forty minutes, butter is formed. The buttermilk resulting from this process is then washed out with pure spring water, salt is added, and the whole mass is worked again until the salt is thoroughly incorporated into the product. Before removal from the churn, laboratory tests are made to determine whether the butter attains the desired standards. Following removal from the churn, it is tempered by allowing it

to remain in a cooler at 30° F. for 24 hours. The product is then cut into prints, wrapped in parchment or in waxed paper, placed in cartons, and packed in containers which are stored in coolers, awaiting shipment to branch houses.

The first problem in butter manufacture to receive adequate attention in modern creameries is uniformity. The consumer wants as nearly as possible the same kind of butter in winter as in summer. Cream gathered from a great variety of farms covering a wide area of differing climatic and feed conditions requires a system of butter making which will equalize the numerous extremes. This factor of differing quality of cream is of importance in locating creameries, for care must be exercised to insure that neither cattle herds nor climate will vary materially. Such progress has been made that butter may be produced within a radius of 600 miles so nearly alike that one cannot distinguish a package of a particular brand from that of another creamery operated by the same company. Such methods of production have stabilized and stimulated distribution. Precision in technique in churning and wash-water temperatures, in maintaining a definite degree of acidity, and in perfect pasteurization have insured a quality of butter uniform in body and sweetness.

Next to uniformity in method, pasteurization has done more than any other process to produce good quality butter. For example, it greatly reduces all bacterial growth in milk and cream, and makes possible a ripening, with a uniform bacterial content. Aberrant flavors in butter are taken care of in the central creamery by grading out the so-called "off" flavors, e.g., wild onions in spring. Such cream is churned separately and, therefore, does not injure the cream of good flavor. After pasteurization has reduced those bacteria which produce acidity, they are replaced by inoculating the cream with certain pure strains of lactic acid bacteria which have been developed for this purpose in pure, sterilized milk. This latter product is known as "starter."

Modern churning is of great importance. At the present time a single-lever churn produces 1,000 lb. of butter in one and one-half hours. After working, the butter has a smooth, uniform color

and good texture, indicating proper distribution of the salt and moisture. None of the butter is allowed to be taken from the churn until the water and salt content have been determined and found correct.

Through the use of well-equipped laboratories, development of the creamery business has been along systematic lines. Careful laboratory control in the plant is the prime requisite in the manufacture of good butter. Intensive research for continued betterment of the product is constantly being conducted, while competitive buying and selling conditions, together with the rigid laws that govern the quality of butter, make it essential that a thorough check be kept on the production of every plant. At the same time this check is used as a medium to produce maximum yield and finest quality with the greatest possible economies. Laboratories in local creameries are under the direct supervision of a central chemical laboratory.

Butter Standards and Storage

The butter business is based on standard, or uniform, quality product; and modern butter standards can be determined by chemical analysis and by market grading. The latter method is really a question of personal opinion on the part of experts, and may be arrived at in several ways. For example, there is a score-card method by which such quality factors as flavor, texture, color, salt, and package are each rated separately, and their total sum is the so-called "score" of the butter. Another method of rating is followed by government inspectors, who likewise pass on certain quality factors. However, this scoring of butter can only be the personal opinion of one individual, based on his estimate of perfection. Since this grading is personal rather than mechanically scientific, it is by no means precise. It often happens that an expert judge will score differently two separate samples from the same churning. Butter scores also vary during the year, and allowances must be made for the season and region in which the butter is produced.

Modern methods of food storage, especially of perishables, are

based on refrigeration. This is a complete change from earlier practice. Today it is the policy to store the finest product even before shipment. For example, June butter is stored because it is the best, and it is necessary to carry butter in storage from a season of large production over to a period of small production in order to supply the needs of consumers. Therefore a product is frozen in order to offer the best possible quality at a time when fresh supplies lack flavor and uniformity. The storage of butter shows the best result in texture, flavor, and quality when the product is carried in a sharp freezer at a temperature of zero and below. The reason that such low temperatures as 10° below zero are worth the added cost of maintenance in large cold-storage warehouses is that such cold retards bacterial action so effectively that the bacteria are almost dormant. As a rule, butter is placed in storage during the season of greatest production, i.e., from June to October, and the heaviest tonnage of butter is normally in cold storage by the first of September. From October onward, a reduction begins, and withdrawals are heavier than receipts until the month of May.

Butter and Cheese Prices

The trend of butter prices, and the causes for their rise and fall, can be treated in connection with cheese prices, for prices of butter and cheese are influenced by the same conditions, and usually are affected in about the same manner. When butter prices rise, cheese prices are also inclined to rise, and conversely, when butter prices fall, cheese prices are likely to decline. However, it should be noted that the butter price is usually more variable than that of cheese. For example, if a "bearish" influence is evident in the market, butter prices are inclined to drop farther than cheese prices, and when there is a "bullish" influence present, butter prices are likely to advance a greater number of cents per pound than cheese prices.

Consumption of dairy products is on a rather stable basis, like meat consumption; yet the demand of consumers is affected greatly by industrial and employment conditions. In any particular

region demand may vary greatly according to local influences which may not appear in a general view of the country. However, supply may be a somewhat greater price influence, since it is neither regular nor uniform in quality, conditions which are reflected directly in the butter markets. The factors which mainly influence the supplies of butter at terminal markets include those of weather, stocks in cold storage, interference with railroad traffic, and changes in price. The most important of these conditions for butter is weather. This factor dominates the seasonal production, for, as already mentioned, the summer months of June, July and August are those of heaviest receipts, because the weather makes possible green pastures and forage crops in abundance, which stimulate milk production in dairy herds. As a result, in the butter business there is a summer period with heavy receipts and low prices, and a fall period with decreased receipts and increased prices. The spring period begins with low receipts and high prices, and gradually develops an increase in receipts with declining prices.

Refrigerator stocks also influence prices because the same amount is not stored each year. Butter storage is necessary, since production is seasonal. For example, stocks enter storage largely in June and July, whereas the quantity taken out gradually increases from September 1 to January 1, and then decreases until the middle of April. Thus supply and price are stabilized. On the other hand, prices influence the amount in storage; for if butter is still high in price during June, July, and August, the tendency is to put less product into the refrigerators. Another considerable factor in prices is that of imports, for large quantities of butter are frequently imported. While most of the butter imported into New York is consumed there, it nevertheless has an influence on the price of butter at Chicago and other points. Often the news of imports influences the market more than the actual arrival of the goods at a later date.

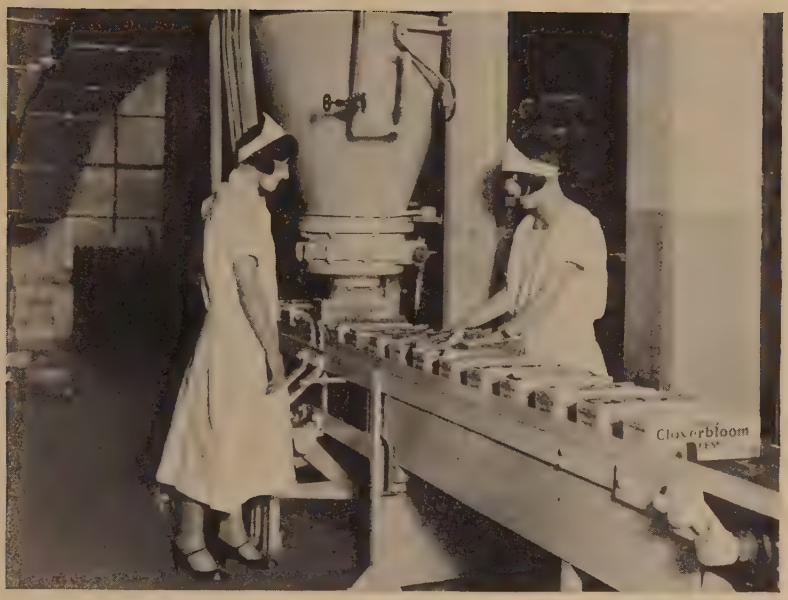
In efficient distribution of butter there are two phases to be considered. While, as with the distribution of all products on a national scale, it is necessary for the distributor to have a funda-

mental knowledge of the requirements of different markets, for the centralized creameries there is a peculiar situation with regard to their supply of raw material, which complicates the marketing problem. Any creamery is compelled by circumstances to make a grade of butter dependent on the quality of its raw material. This differs from one region to another, and therefore it is necessary for creameries to adjust the outlet of their butter to the volume of their supply of cream; in other words, the problem is to find a market for the varying quantities of butter produced at a particular plant.

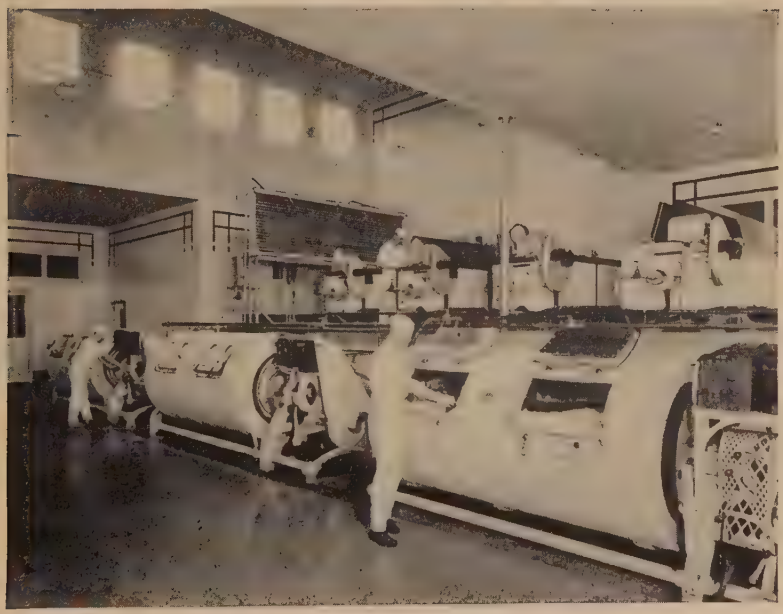
The Cheese Business

The cheese business is important for some packers because it furnishes another dairy product for marketing through their distributive organization. Like butter, cheese is a nutritious, healthful, concentrated food product, whose manufacture and distribution on a commercial scale has grown rapidly until the total yearly volume has reached over $130,000,000. Along with the increased amount of cheese made and distributed have gone progressive changes in production methods. It is a remarkable fact that, from the very earliest times until the last two decades, very little progress or change had been made in the making or marketing of cheese.

In general, the production of cheese differs from that of butter in being confined to one or two regions, rather than spread over the whole country. While a considerable amount of cheese making is carried on in many states, Wisconsin produces about three-quarters of the total cheese made in the United States at the present time. The movement westward of the center of the cheese business from New York state, due to the increased demand for raw milk from urban centers in New York, has been responsible largely for the increase of the cheese industry in Wisconsin. Other reasons are that the conditions in Wisconsin are ideal for dairying, and competition from raw milk distributors is as yet a small factor. However, it is likely that with the growth of large urban centers in the Middle West itself, there will be a still further west-



PACKAGING CHEESE



BUTTER CHURNS IN OPERATION

ward trend in the cheese business. Finally, Wisconsin cheese carries prestige because of certain stringent laws which require a specially high quality in the product.

Cheese Manufacturing

Cheese is the solid content of milk (butter fat, casein, etc.) pressed into form. It contains some moisture, though its solidity depends on the curdling or coagulation of part or all of the protein, and the expulsion of the watery part, or whey. The coagulum or curd so formed incloses part of the watery portion of the milk, part of the salts, part or all of the fat, and an aliquot part of the milk sugar. While raw materials and the details of the manufacture of cheese vary considerably with the different types produced, the fundamentals of cheese making are substantially the same for all kinds. These different varieties, types, and flavors of cheese are the results of refinements in curdling and curing, and the development of different bacteria.

The type of cheese most widely made and used in the United States is the Cheddar type, which is usually known as American cheese. The name of this cheese originated in the town of Cheddar, England, and the English people are the largest per capita consumers of it. The United States produces about 40 per cent of the world-supply, namely, 400,000,000 lb.

A brief description of Cheddar cheese manufacture will serve as an illustration of the methods employed in making all cheese which is distributed by packers. The milk is received at the factory from the surrounding farms early in the morning. It is first placed in the weighing vat to check the weight, after which a sample of each lot is taken for analysis. The milk next flows to a large vat in which the first steps of cheese making take place. These vats contain from 6,000 to 8,000 lb. of milk, or approximately 3,000 to 4,000 quarts. The milk is warmed to a temperature of 86° F. by letting steam into the water surrounding the bottom and sides of the jacketed vat. A lactic acid "starter," or culture, is added to the milk to initiate the souring function, and is thoroughly

worked in with what is known as a cheese rake. After this, a pure vegetable coloring is incorporated, which gives the attractive yellow color to American cheese.

Next, rennet is added to hasten coagulation: about 3 oz. of rennet extract, diluted in forty times as much water, is used to 1,000 lb. of milk. This rennet, in extract form, produces a curd which will permit desired ripening changes to take place. Due to the comparative scarcity of rennet at times, pepsin is substituted in certain factories. Rennet is made from the ferments of the digestive stomachs of calves, pigs, and sheep. These stomachs are taken from the animal, cleaned, inflated, and dried, and are then held in dry condition until needed for use, the juices being extracted by placing in a water solution. The rennet extract itself is in either a liquid or granular form. Pepsin is made from hog stomachs and is dissolved in lukewarm water and used in this form for coagulating milk for cheese making.

Once again the cheese rakes are actively engaged in thoroughly mixing the rennet for 3–5 minutes. The milk is then left undisturbed and begins to show coagulation in from 15 to 20 minutes. In about 30 or 40 minutes, when the milk is sufficiently clabbered, or the curd is quite firm, it is ready to cut. This is done with curd knives, first cutting vertically from one end of the vat to the other, and then crosswise. The purpose of cutting the curd is to allow the whey to escape from it. The small pieces of curd are kept floating in the whey by gently stirring with a wooden rake to prevent the curd from settling and packing in the bottom of the vat. By means of active stirring and gentle heating, the proper body and acidity are produced. The whey is then drained off, leaving a mass of curd at the bottom of the vat. The next operation is known as ditching, when the curd is drawn to the sides of the vat to allow drainage.

Cheddaring, or milling the curd, is the distinctive feature of the Cheddar method of cheese making. It consists of two operations, namely, piling or matting the curd, and cutting the curd into strips and continuing the operation of piling and repiling. After the curd has been allowed to stand for ten or fifteen minutes it

is cut into large pieces, which are turned and returned in order to expel any whey that may remain. These pieces are cut into strips and put through a milling machine, which breaks the matted cheese into small particles. The mass of curd is salted and again thoroughly stirred, so that the salt will be evenly distributed. In this operation 2 or 3 lb. of salt are used to 100 lb. of curd. After salting, the curd is cooled to about 80° F., and is then ready for packing in the hoops in which it is to be pressed.

The hoop is usually a cylinder of sheet iron, heavily tinned, with a wooden or metal plate, called a "follower," on which the pressure is applied. The hoops are slightly tapered so that one will fit into the other in order that a horizontal press may be used, and a row of ten or fifteen hoops can be pressed in one operation. Before the curd is put in, the hoop is lined with a cheesecloth known as a bandage, and this cloth remains on the cheese when it is taken out. The press most commonly used is known as the "continuous pressure" type. The weight of the cheese, through a cantilever arrangement, exerts a constant pressure against the end plate, hence the term "continuous pressure."

There are a number of shapes into which American cheese is molded. The various shapes are known as long horns, young Americas, prints, daisies, twins, Cheddar, etc., and a factory is usually equipped to make all styles, although some factories specialize in certain types. The latter three types are most popular since the advent of the 5-lb. tinfoil-wrapped loaf.

After eighteen hours in the press, the cheese is taken out of the hoop and placed on a shelf in the curing room, where an even temperature must be maintained. About 70° F. is considered the best; and after the cheese has been on the shelves for a week or more, it is shipped to concentrating warehouses for further ripening and paraffining.

Varieties of Cheese

Cheese may be classified into various groups. From one commercial point of view, cheese may be divided into two groups, bulk and package, with a total of 250 varieties. Both bulk and

package cheese have a classification of various styles. The bulk type of cheese is known as American, or Cheddar. At the present time cheese is widely distributed in packages, in conformity with the practice for many other goods.

Again, a rather common classification of cheese, from the manufacturing point of view, is that of soft and hard cheese. Soft cheese is more quickly perishable, since bacteria and molds grow more favorably where there is considerable moisture. This produces changes in appearance, texture, odor, and taste, due to deterioration. Such cheese requires careful refrigeration conditions in distributing it. Some varieties of soft cheeses are eaten fresh, and others, such as Camembert, are ripened before being consumed. In contrast to the soft cheeses, hard cheeses are low in water content, ripen more slowly, and may be kept for much longer periods. They retain their form through a wider range of climatic conditions, develop flavor more slowly, and deteriorate much less quickly.

Any class of cheese may be turned into processed cheese by being run through mixing and molding machines, and re-packaged into forms different from that characteristic of the original variety. In this processing, substances such as pimento may be added to change the flavor to suit a particular trade. One great advantage of packed and pasteurized cheese has been the greater uniformity of product, with more dependable flavor and keeping quality. The purchaser may now obtain exactly the same cheese as to flavor and texture year in and year out. Since this new development began, cheese consumption in the United States has increased about one pound per capita.

From still another commercial standpoint cheese may be roughly divided into two general classes, viz., those in which the curd is produced through the action of rennet, and those in which it is formed by means of lactic acid.

Of the latter class the cottage and Dutch cheeses are the types most familiar. To make these, whole milk is allowed to sour, then heated to separate the curd from the whey, when the curd is formed into balls or cakes. Cream or butter is sometimes mixed

in to enrich it. These types of cheese require no ripening and must be used very soon after making; otherwise they develop molds which spoil the flavor and render the cheese unfit for use.

Countless varieties of cheese are produced through the action of rennet upon milk. Differences among these varieties are due to several factors: differences in the source of milk, whether from the cow, goat, or sheep; the amount of moisture retained in the curd; the amount of salt and the nature of certain spices or other materials added; the size of the cheese cake; temperature and conditions of ripening; the presence of certain organisms, particularly molds and bacteria, which are in some cases intentionally added and in others are normally present under the conditions of manufacture.

Again, the rennet cheeses may be divided into the hard and the soft types, the principal difference between them being in the amount of moisture or whey left in the curd. The most common types of hard cheese are the Cheddar and Swiss. The soft types comprise the Neufchatel, Brie, Camembert, etc. Between these two groups are varieties which may be characterized as semihard, such as brick, Muenster, and Limburger. As a rule, in the hard cheeses the micro-organisms which produce the "ripening" are distributed through the cheese mass and therefore act in a fairly uniform way throughout the cheese. In the soft cheese these organisms are mostly on the surface and gradually penetrate through the mass. Hence it follows that soft cheeses must be made in small sizes.

From a description of Cheddar cheese making, it is apparent that it is the lactic acid bacteria which are largely responsible for the resultant product. In general, the first stages in the process of making the different varieties of rennet cheese are much alike. It is in the latter stages of ripening, with the consequent development and action of bacteria, that the changes occur which make the great differences observable in texture, body, and flavor.

Swiss cheese.—Swiss cheese, which is in the hard cheese group, is often called the king of cheese, from its large size, fine flavor, and the remarkable appearance of the round holes in the

cut surface, called "eyes." The trade prefers winter-made Swiss because of its chalklike whiteness, which in no way affects its flavor. The difference in color is due to the fact that the summer cheese is made from milk produced while the cows are on grass feed, when the milk has more color than when the cattle are dry fed. Fancy Swiss cheeses have large well-defined eyes; No. 1, well-defined eyes that are not quite so large as in fancy; Medium-eyed, still smaller eyes, which are not necessarily well defined.

Swiss cheese is made by a special process, the milk being heated and coagulated in copper kettles with round bottoms. The curd is removed in one piece by using a half-hoop, which carries the draining cloth under the curd and enables the curd to be lifted from the kettle and placed in the hoop to drain and take form. A special culture of bacteria, which produces the formation of "eyes," is added to the milk before it is coagulated, and the development of the eyes is controlled by the temperatures maintained in the curing rooms. The salting is accomplished by holding the cheese in a brine solution for several days during the process of manufacture. The cheese is usually held in the curing rooms for three months or more before it is marketed. Imported Swiss cheese is packed three or four wheels to the wooden tub and averages 200–250 lb. to the wheel. Domestic Swiss is packed four or five wheels to the tubs, the wheels running somewhat smaller than in the imported.

Semihard cheese.—The foregoing comprise the varieties of hard cheese most often found in markets. A different type of cheese is characterized as semihard, of which Limburger is one of the best known varieties. The first grade of Limburger is made from whole cows' milk, although part-skim or skim milk is used for certain grades. It originated in Belgium, but was first marketed in Limburg. Its manufacture has spread to other parts of Europe, notably Germany, as well as to the United States, where large quantities of it are made both in New York and Wisconsin. Contrary to popular opinion, due to the very strong and disagreeable odor of this cheese, the manufacture of Limburger cheese requires greater care, and more constant and unfailing attention

to all details of cleanliness, than any other variety of cheese, with the possible exception of Camembert. Unlike the procedure in the Cheddar process, the curd is usually not cooked, although sometimes it is necessary to raise the temperature to about 98° F. to expel excess moisture. The characteristic pungent flavor is developed during the ripening process, which requires at least two months before it is complete. During this time the color of the outside of the brick changes from a whitish to a yellowish and even reddish brown. The disagreeable odor seems to be confined almost entirely to the rind, so that when this is taken off and the Limburger packed in tins or tinfoil packages, most of the delicious flavor is retained, while much of the objectionable odor is lost.

Both brick and Muenster cheeses are much like Limburger in their process of manufacture. Brick cheese gets its name from the size and shape of the finished product, and in its process of manufacture is midway between that of the Limburger and Cheddar types. As in the case of Limburger, it is the change taking place during curing which determines the characteristic flavor. During curing, the surfaces of the cheese are kept moist, and undesirable mold growths are prevented by rubbing the cheese with salt water. About four to six weeks are required for perfect curing. Good brick cheese is neat and attractive, with cut lines and unbroken rind, and a clean, sharp characteristic brick flavor, with mellow body and smooth texture.

Muenster cheese originated in Germany, near the city of that name, but there is a limited quantity made in America. As to method of manufacture, it is midway between that of Limburger and brick cheese in temperature used, firmness of curd, amount of moisture, time of curing, etc. This cheese is often made by Limburger factories in the late fall and winter, when it is difficult to manufacture the Limburger.

Soft cheese.—Chief among the strictly soft varieties of cheese are the Brie, Camembert, Neufchatel, and cream. These types of cheese are all more perishable than the hard varieties, some of them requiring constant refrigeration in order to keep for even a few days. Neufchatel is of French origin, although extensively

manufactured at many points here. It is made of all grades: the finest, from whole milk; but usually from skimmed, or low-grade milk which cannot be used otherwise in cheese making. The quality of the product varies with the skill of the cheese maker, from brands no better than cottage cheese to products hardly distinguishable from the best whole-milk Neufchatel. Many factories produce more than one grade of Neufchatel.

Cream cheese is made by the same process. The material used, however, is what is called double cream, made by taking the cream from one-half a given quantity of milk and adding it to the other half. Both of these varieties are forced through a mold, and then wrapped in tinfoil wrappers for the market.

Camembert cheese first came into active notice during the reign of Napoleon, so that the legend that he named it may be true. In the making of Camembert cheese more than the ordinary care is taken to secure exactly the right conditions favoring the growth of the peculiar organism. Very frequently cultures of this organism are secured from dairy laboratories to make sure that the characteristic growth of mold is induced. The later stages of ripening take place after the curd is wrapped in tinfoil and placed in the little wooden box in which it is marketed. When ripe, the cheese is covered with a grayish-green glistening mold, sometimes with reddish slimy masses directly in this mold. Inside the mold, the cheese is softened all the way through to about the consistency of soft butter. In color it is rich and creamy.

The varieties of cheese which have been described and which are distributed by packers comprise only a few out of the many hundred known throughout the world. In many instances the same cheese may be known by a half-dozen names in as many localities. In addition, there are countless kinds of package cheese marketed under various brand names.

Cheese Prices

For the general cheese trade the market prices are established in an interesting way. Since Wisconsin produces most of the cheese in this country, it is natural that the basic cheese

price should emanate from that state. At Plymouth, Wisconsin, a weekly cheese market is held where values are established for the following week. This basic price covers unfinished cheese in an unmarketable condition, i.e., as it comes from the curing room in the cheese factory. However, the manufacturer buying his cheese on this market and in this condition, performs certain services and is subject to certain expenses which increase the cost over the price paid by him to the factory. The concentration stations of the packers have such expenses as freight, additional shrinkage before paraffining, and such incidental costs as brushing, paraffining, scale boarding, reboxing, labeling, etc. It is only after these expenses have been added and a reasonable profit figured, that a final sale price can be determined for quotation by all factors in the packers' distribution system.

Standardization and Inspection of Cheese

Distribution of cheese is performed on a basis of grading made possible by certain methods of standardization and inspection. These are localized by different markets, but in order to put the matter on a national basis, tentative systems of grades have been prepared by the United States Department of Agriculture, the Chicago Mercantile Exchange, and the Wisconsin State Department of Markets. The usual ratings on various quality factors are: flavor, 30; body and texture, 40; finish and appearance, 20; color, 10. In inspection of cheese, flavor is considered from the standpoint of degree of development and quality. For example, a newly made cheese does not have a well-developed flavor and aroma. Normally, it has a raw curd taste, and therefore is classed as fresh cheese. A cheese that has been held in the curing room for some time and has a moderately "nutty" flavor is classed as mild, and cheese which has considerable age, has ripened more fully, and has a more fully developed flavor or rather sharp taste, is classed as aged cheese. The degree of flavor is described as "fresh," "mild," or "aged," according to the extent of its development. Quality of the flavor of cheese may be classified from point of view of palatability as highly pleasing, de-

sirable, slightly objectionable, objectionable, poor. The body and texture is tested and indicates the following characteristics: solid, firm, medium firm, soft, silky, smooth, whey, stiff, corky, mealy, crumbly, dry, watery, weak, pasty, salvy.

Canned Food Side Lines

Milk powder is one of the newer of the milk products which have come into general favor among food-product manufacturers, and is also in favor in many households because of its economy and convenience. It is manufactured either as skim-milk powder, whole-milk powder, or cream powder. Except for the small percentage of water or moisture in milk powder, it has the same relative composition as the total solid content of milk or cream. The general uses of milk powder correspond to the product from which it is made, for most powder is readily soluble in water; and when the proper amount of water is added to the powder, and it is dissolved, it has practically the same flavor, taste, and characteristics of the original milk. The process of reducing fresh milk to a powder which, by addition of water, is restored immediately to its original state, has improved considerably during the last few years. Indeed, it is difficult to discriminate between this mixture and ordinary fresh skimmed milk. In powdered skimmed milk, the cream, including the bulk of the fat, has been removed in order that it may keep longer in perfect condition. When a little cream is added to this solution, the preparation is restored to the value of the whole milk.

Milk powder is made by the spray process, as follows: After separating the butter fat, the skim is condensed and cooled, and forced by a high-pressure pump through a spray nozzle so that it comes out in the form of a cloud or mist. This milk spray, entering a chamber through which a strong current of filtered warm air is blowing, is whirled about just as clouds of snow or fog are blown by the wind. The moisture in the milk spray is absorbed by this warm wind, and the solid portion falls like snow in drifts of powdered milk. The moisture-laden air passes out through muslin screens which prevent any of the powdered milk from escaping.

This process removes nothing from the milk but water. Therefore, when water is replaced, the result is milk, with true milk flavor.

The advantages of powdered milk are numerous. It is a pure milk, reduced by a process in which none of the nourishing properties of milk have been affected, and where no bacteria multiply. It is clean and pure and is uniform in quality, freshness, and flavor. On account of the absence of moisture it keeps fresh longer than other forms of milk. Buttermilk powder has come into commercial use in pancake flours and self-rising biscuit flours, and also as a component part of prepared commercial poultry and stock foods. Likewise, cream powder is, in fact, powdered cream. It may be made from cream containing from 8 per cent to 50 per cent butter fat. When dissolved in the proper amount of water it has the composition of cream and may be used for the ordinary purposes for which cream is used.

Whole-milk powder is especially suited for household use, and, like cream powder, is packed in one-pound and larger containers. In recent years whole-milk powder has come into growing use for infant feeding. In fact, most infant food preparations in powder form contain milk powder. Skim-milk powder is manufactured extensively and is used largely in confectioneries, bakeries, ice-cream factories, and milk-chocolate factories. Buttermilk powder is used principally in the manufacture of pancake and other prepared self-rising flours, and also in compounding poultry and stock feeds. During the war there was a large demand for milk powder. Today it finds a market in places where fluid milk of satisfactory quality is not easily obtainable, or the prevailing retail price of fluid milk is rather high. One hundred pounds of skim milk will produce about nine pounds of milk powder.

Condensed and evaporated milk are very much alike in composition, except that condensed milk contains approximately 35 per cent of cane sugar. This additional sugar gives condensed milk a heavier, creamy syrupy consistency, making it especially adapted for use where cream and sugar are used together, as on cereals and in coffee. Condensed milk is marketed in cases and

in bulk, the former being, in the main, for household use, and the latter for wholesale trade, such as bakeries, confectioneries, and ice-cream factories. In the manufacture of condensed and evaporated milk, the milk is placed in the condensing pan and heated to a temperature of 135° under a vacuum of 25 inches, and the water is evaporated until the milk has been reduced to about three-fifths of its original volume. The evaporated product has about two and one-half times the percentage of total solids in normal milk. Milk which is marketed in evaporated form is usually passed from the condensing pan through a homogenizer into the final containers, where it is hermetically sealed. It is later placed in a steam-pressure sterilizer, where it is held for 15 minutes or more until it has been thoroughly sterilized, thus insuring its keeping quality. Condensed milk, i.e., the sweetened product, is not sterilized, as its sugar content contributes to its keeping quality.

Condensed and evaporated milk is packed in large and small cans, the standard large size being 16 oz. for evaporated, and 14 oz. for condensed. In the usual channels of trade these products are sold to the retailers by manufacturers' agents and wholesale grocers. Shipments are made usually in carload lots from the factories to the agents or wholesale grocers, who in turn ship or deliver to the retailer.

There are many varieties of canned fruits and vegetables which are distributed by meat packers for the same reason that they distribute produce. Among them are tomatoes, peas, beans, asparagus, apples, apricots, cherries, grapes, peaches, pears, pineapples, plums, blackberries, loganberries and raspberries. A number of fruits are also dried and sold in that form. Still others are made into preserves and jellies and have a wide distribution. Various condiments are sold which are canned and put up in jars.

CHAPTER XIV

MANAGEMENT OF BY-PRODUCT MANUFACTURE THROUGH ACCOUNTS

The array of by-products discussed in the preceding chapters is such that their economical and efficient production requires organization and control of a somewhat different kind from those used in other industries. For by-products in the packing industry are the result of a *disassembling* process, while in other industries they are made of otherwise waste materials of the main process, which is an *assembling* one. In meat packing the practical and technical operation of by-product manufacture is reflected in the accounting methods employed. In other words, the accounting procedure is the language used to explain the results of the actual operations of the business.

The *raison d'être* and aim of every individual business is financial profit. Therefore, every new product added to those manufactured and distributed by any firm is expected to increase the total financial return. But in the case of by-products there is a particular reason why the management procedure, through accounts, differs from that in other businesses. An explanation of the accounting methods used in the operation of by-product manufacture is necessary in order to present a comprehensive picture of these operations in the packing industry. By means of an application of the economic theory of joint costs back of by-product manufacture, the relations of the various phases of the business are clarified and co-ordinated. Furthermore, in order to present a clear picture of by-products, what they mean, and the part they play in our economic life, there is necessary not only a discussion of the raw materials, their technical processing, the distribution of the finished product, the effect of tariffs and other factors upon distribution and price, but an analysis of the whole operation from the point of view of the executive responsible for the profitable

financial management of the whole enterprise. This business management of the operation is through proper accounting, which, in by-product operation, is based upon the theory of joint costs.

The Joint-Cost Problem in the Packing Industry

The meat packer buys an animal which must be sold in the form of a variety of products. Since he pays a specified amount per hundredweight for this animal, he can only approximate the cost of the constituent parts, his methods being indirect and often very arbitary. The variety of ways in which such an accounting may be accomplished is responsible for the one-time prevalent public opinion that the packers' figures can be manipulated to meet the political aspects of any question. Since the war an interesting example capable of such interpretation has occurred in the beef trade. One large packer, paying approximately the same prices for cattle and selling his beef, hides, and by-products at approximately the same levels and in the same markets as his principal competitors, has shown losses on his beef operations when others were showing profits. Yet at the end of the year it often happened that the total business profits of each of the packers under consideration were proportionately the same, which fact served to arouse distrust of the honesty of the packers' records on the part of the producer and many consumers.

The explanation is not difficult. If two such packers use different systems in crediting their cattle with the hides, fats, and other by-products yielded, so that in one case the amount of credit is materially greater than the other, the apparent cost of the beef varies considerably. Although this beef may sell in each case in the same markets, the selling price may fall between the two costs in such a manner that one packer is apparently losing money on his beef sales while the other is apparently securing a profit. Many of these systems of accounting have grown up through custom, and the obtaining of a uniform system is fraught with grave danger in a field where no particular method can be declared either right or wrong.

To clarify the situation one might take the example of beef

tongues. If a fat steer costs 12 cents a pound, what is the cost of his tongue? Similarly, if a canner cow costs 5 cents a pound, what is the cost of her tongue? Is the ratio of cost between the two tongues a ratio of 12 to 5? If the selling market shows a difference of only 2–3 cents between the two kinds of tongues thus secured, should this fact have any effect on the cost as calculated by the accountant? If one packer uses simply an average value for tongues in calculating his costs, and another grades his into four or five classes and applies the average value to each grade, which one is following the correct procedure? Sometimes the market differences will be such that the extra effort involved in this careful grading will pay; at other times it will not. At any rate, the average value for beef tongues cannot be known accurately unless the relative proportions of each grade of tongue produced by a packer from each day's slaughter are definitely and accurately recorded. Otherwise the figure is just a guess. The problems raised in the foregoing discussion apply to all other by-products: livers, hearts, melts, tripe, fats, casings, hides, etc. The remarkable situation in connection with the problem is not that packers differ, but that they so nearly agree in the methods of accounting which they have used.

Broadly speaking, and from the standpoint of cost finding, industrial operations fall into two classes: those in which materials are put together, or built up, into a finished product, and those in which raw materials are taken apart, or broken down, into several or many products. The first class covers the ordinary manufacturing operations which are dealt with by the rules of normal cost-accounting procedure. The second class refers to those industries which involve joint operations, and can be divided into (*a*) those operations which result in one major or prime product and one or more by-products: and (*b*) those operations which result in several joint products of varying values, none of which constitutes a major product. An adequate and practical theory of joint costs had to be evolved in order to enable the national packing industry to develop large-scale by-product operation intelligently and economically. Only by the use of scientific measures was it possible

to increase the number of by-products and their commercial benefits for other industries and trades as well as for the consuming public. The Institute of American Meat Packers has appointed a committee on cost accounting which has succeeded in unifying many of the divergent principles involved, and which has laid the foundation for the determination of further costs which have hitherto been considered entirely indeterminable.

Different Types of Industries and Cost Formulas

Explanation of the underlying ideas may be best obtained by a study of the broader field of industry. As suggested by this brief discussion, there are three classes of manufacturing operations, each of which have different principles of cost finding: (1) Manufacturing operations which consist of putting together or building up materials, labor, and factory services into a finished product. (2) Manufacturing operations which consist of separating or breaking down raw materials into several or many parts, one of which is a major product and the other a by-product. (3) Manufacturing operations which consist of separating or breaking down raw materials into several or many parts called joint products, no one of which may be considered a major product. Consideration of these three different types of manufacturing operations is essential to an understanding of cost-accounting procedure in the various lines of industry. The first type of operations consists of those commonly thought of in connection with general manufacturing businesses, and include the production of implements, automobiles, clothing, shoes, furniture, machinery, boxes, etc. The second type of industrial operations which involve a major product are found in such important industries as coke production, flour milling, vegetable oil refining, and the beef, veal, and mutton businesses. The third type of manufacturing operations which involve joint products may be illustrated by the tobacco industry, the production of chemicals, petroleum refining, and the pork-packing business.

It is impossible to apply the principles and procedure of cost finding for ordinary manufacturing operations to the last two

types of industries. This becomes clear in analyzing the cost formulas for the three types which illustrate the order of steps taken in determining net profit and the general principles which must be observed. For the first type of operation, namely, the fabrication type, the following procedure is used: (1) Take the cost of raw materials. (2) Add labor costs. (3) Add operating and overhead expenses. (4) Total to secure factory cost. (5) Add selling expense. (6) Add financing expense. (7) Total to secure total costs. (8) Take gross sales value. (9) Deduct total costs. (10) Final figure is net profit.

The foregoing determination provides the manufacturer with information on the net results of his business, and, by application to individual products instead of to the total business, permits him to find costs and profits on such products. For operations which yield a major product and by-products, however, the accounting is not so simple. The usual procedure is to determine the cost of the major product only. This is accomplished by deducting from the total cost of all operations the net realizable value of the by-product, the actual cost of which cannnot be separately calculated. The formula and procedure used are indicated in the following: (1) Take the cost of raw materials. (2) Add labor costs. (3) Add operating and overhead expenses. (4) Total to secure factory costs. (5) Deduct the credit for by-products. (6) Result is cost of major product. (7) Add selling expense. (8) Add financial expense. (9) Total to secure total costs. (10) Take sales value of major product. (11) Adjust for difference in sales value of by-products as compared to credits. (12) Subtract total costs. (13) Result is net profit.

The determination of profit just given of course offers no opportunity to secure the individual costs of the separate by-products; nor has any satisfactory method ever been devised. The credits for by-products are determined on the basis of the current market at the time they are yielded, but the net profit can, of course, only be determined when the necessary corrections for actual sales income are made in comparison with the estimated values at time of production based on the "going" market. In

some instances in the packing industry there is no "going" market for the raw material used in by-product manufacture, and the value used in accounting must be based on the relationship between the selling price of the finished by-products and the cost of manufacture.

For operations which yield joint products of different values, there is no means of finding individual costs of any products. For theoretical purposes, one might treat each product separately as a major product and use the system described for the second type of manufacturing operation; but such information is only empirical and will never yield information of practical value for the ordinary course of commerce and manufacture. Therefore the following simple steps are all that prove practicable: (1) Take the cost of raw materials. (2) Add labor costs. (3) Add operating and overhead expense. (4) Total to secure factory costs. (5) Take the total net sales value of various commodities. (6) Deduct the costs secured under (4). (7) Result is net profit.

The net sales value of various commodities mentioned under (5) is secured by deducting the selling and financial expense. From the standpoint of net result, it probably makes no difference whether this expense is deducted from the sales value or added to the costs as in the previous methods, but in the determining of cost of products and net profits it is essential that they be removed from the calculation in advance of such a determination.

"Opportunity costs" is the term applied in the second and third types of accounting to costs of individual products which cannot be determined in actual money. The theory of these costs gives a method for arriving at a value for such products on the basis of which they are transferred from one manufacturing stage to the next. In the case of major and by-products, opportunity costs represent the value which the manufacturer has the opportunity of obtaining if he desires to dispose of such by-products; or, in other words, their current market price.

Where by-products are concerned, the manufacturer usually has two alternatives. He may either sell them at their present market price, or he may assume the risk of converting them into

manufactured products. If the latter alternative is accepted, the cost of the by-products when transferred for subsequent operations should be the amount which the manufacturer has had the opportunity of getting for them. The opportunity costs of joint products are similarly the value which the manufacturer can get for them if they are placed on the market. This action is fundamentally correct because he has the alternative of retaining the joint products for processing into further stages of manufacture. If so retained, the cost of such products to the subsequent operations is the amount which he had the opportunity to obtain for them.

Joint Costs in the Cattle Business

The cattle business in the packing industry is a good example of joint operations resulting in major products and by-products. The raw materials are live cattle. The major product is the carcass of dressed beef, while the by-products include hides, oleo oil, stearine, tallow, tongues, and other edible small products, as well as bones, horns, tankage, etc. The carcass of dressed beef, being the major product, is the largest single product coming from these operations, and represents about 45–60 per cent of the live weight of the animal. A very significant market ratio exists in this industry between the dressed beef market and the live cattle market. Both of these markets are very sensitive, fluctuating from day to day as conditions change within each market. The fluctuation in the prices at which beef and by-products may be sold reacts upon the market for live cattle with striking promptness. These sensitive and fluctuating market prices are the only possible means by which cattle are attracted to livestock markets or kept away, and the production of beef is adjusted thereby to consumptive demand.

In this cattle business the only factors upon which costs can be based are: (1) At the beginning of the operations there are known the live-weight price and total cost of each lot of cattle purchased. (2) At the conclusion of the operations there are ascertainable: (*a*) the weight of dressed beef produced; (*b*) the number, weight, and grade of hides produced; (*c*) the quantity and

quality of other by-products produced; (*d*) the estimated amount of expenses incurred on such joint operations.

The standard procedure in computing the cost for a lot of cattle is illustrated in the example given in the following table. In this industry, as in many others, there is a very substantial element of intangible shrinkage in the handling of the raw materials. In the illustration the total live weight of a lot of cattle was 52,390 pounds, and the weight of the dressed beef produced was only 29,615 pounds, that is, there is a "yield" of 56.53 per cent. The immediate effect of this intangible shrinkage is almost to double the unit costs of the major product. This shrinkage is probably one of the most confusing factors in the minds of the public, which often wonders why dressed beef sells at $12.00 to $14.00 per cwt. of the carcass, when live cattle sell for $7.00 to $8.00 per cwt. The practice now regularly recommended by the Cost Accounting Committee of the Institute of American Meat Packers is to value all by-products on the basis of market less expenses of processing and marketing such by-products.

ILLUSTRATION OF COST FIGURING IN THE CATTLE BUSINESS

Live cost—46 head, weight, 52,390 lb., average, 1,138; native steers. At $7.00 per cwt		$3,667.30
Expenses—killing, dressing, chilling (estimated)		118.03
Allowance—condemnations, trimming, etc. (average)		17.77
Total outlay on lot		$3,803.10
Deductions:		
Credit for hides (market values less test expense of processing and marketing)	$ 387.03	
Credit for fats (calculated as for hides)	116.30	
Credit for other by-products (calculated as for hides)	125.73	
	$ 629.06	
Balance—Plant cost of carcasses in cooler		$3,174.04
Dressed carcasses weighing 29,615 lb. (give average dressed cost per cwt.)		10.72
Add test selling costs and expenses per cwt		1.89
Total cost of lot per cwt. of dressed beef		$ 12.61

The by-product credit for hides in the foregoing table is arrived at in the following manner: The current market price for the particular class and grade of cured hides considered was $14.40 per cwt., or a total value of $478.80. As the hide will shrink 15–16 per cent in weight during the curing process, and will have to be carried 30–90 days, it is necessary to make allowances for the expenses of curing and selling, as well as for this shrinkage, in arriving at the uncured current value, which in this case amounted to $2.76 per cwt. Deducting these expenses from the current market price of $14.40 per cwt. gives a net credit for the hides of $11.64 per cwt. This price, applied to the forty-six hides weighing green 3,325 lb., gives the credit of $387.03.

In the case of fats, the by-product credit is based on current value of oleo oil and stearine, which are the rendered products of raw fats, allowance being made for yield of oil and stearine and the expenses incurred in rendering. In this instance the current price of oil was $9.50 per cwt. and of stearine was $7.50 per cwt. reduced to a raw-fat basis by stating the value of the yield of oil and stearine from the quantity of fats. With expenses deducted, the result was a value for the raw fats of this class and grade of animals of $4.22 per cwt. The fats from this lot of cattle amounted to 2,746 lb., and at $4.22 per cwt., provided, in their unprocessed form, the credit of $116.30.

Due to the perishable character of the major product and the changes continually occurring in the buying and selling markets for cattle, dressed beef, and by-products, one must have available cost figures within a few hours after the operations have taken place. In figuring costs it is necessary to predetermine expenses by careful tests and to prepare schedules of expenses and by-product values which may be used in figuring the cost of each lot of slaughtered cattle. At the close of a period adjustments are made between the test or preliminary cost and the actual cost and results, due to: (1) the difference between estimated and actual expenses in both major product operations and by-product operations; and (2) the difference between estimated and actual values realized from by-products.

The valuation of by-products at their estimated full realizable value has the effect of showing the full margin of profit or loss on the major product. This is particularly desirable in the beef industry, because of the significant relationship existing between the individual markets for dressed beef and cattle. These markets provide the best illustrations of costs as a guiding factor in buying operations. Industries such as the cattle business, which produce major products and by-products, usually operate on a very narrow margin or spread between material cost and the value of products compared with other types of manufacturing operations, for raw material is a far more important element in the costs than labor and factory expense.

Valuation of By-Products

By-products should be valued on the basis of the conservative current market value of such products, i.e., the value which will be realized upon sale, providing the markets remain unchanged. This is necessary in order to determine correctly the cost of the major product. If the by-products are valued under the market, the cost of the major product is overstated and the operating results thereon consequently understated. If by-products are valued above the market, the cost of the major product is understated and the operating results are overstated. In industries operating on very narrow margins, and consequently having very responsive buying and selling markets, the accuracy of costs is a most vital factor in guiding buying operations, and hence the importance of close approximation to accuracy is continually emphasized.

As by-products should be valued on the basis of the current market at the time produced, the results shown by such by-products upon their sale include the following elements: (1) The difference between estimated and actual costs for processing and merchandising by-products; (2) the difference between estimated and actual yield in quantity and quality of by-products where these are estimated at time of production; and (3) the profit or loss on

by-products due to changes in markets between the time of production and of sale.

Such results should be treated as adjustments to the operating profit or loss shown on the major product, thus arriving at the operating results for the complete line of business. Where several classes of by-products are produced, separate accounting is made for each, in order that operating results and costs may be readily analyzed. Analysis of by-product accounts, as well as supervision of by-product operation, are promoted by comprehensive plant division into departments and accurate departmental accounting. If substantial profits or losses are realized on by-products, it is necessary for operating men in following markets to analyze and check the results, since such profits or losses affect the cost data upon which they rely in operating.

Joint Costs in the Hog Business

The hog section of the packing industry is a very good example of joint product operations. The raw material is the live hog, and the slaughtering operations result in various joint products, among which are the following: fresh hams, shoulders, bellies, loins, fat backs, lard, etc. In this business, markets for live hogs and for pork are intimately related, as their daily fluctuations indicate. The most important function in cost accounting in this business is to express the relationships between the two markets.

As this branch of the industry also operates on a very narrow margin and usually has a very high rate of turnover, changes in the spread between these markets are of the highest significance to the management. Therefore a test or predetermined cost sheet is provided as a basis for judging market conditions, which permits a consideration of the aggregate value of all products from live hogs and of the current market price or cost of the live hogs, together with the operation expense. This procedure indicates the spread between the markets, and is a very important consideration in determining buying policies.

The customary procedure in this industry gives rise to the

common cost-finding practice illustrated in the accompanying test cost form (Table XXV). This form may be used for the purpose of judging markets by simply computing the amounts on the basis of current market prices for products and for live hogs. The form is also used in accumulating the actual costs and results of transactions. It may be simply a test which a merchandising executive may fill out with current prices to illustrate the market

TABLE XXV

TEST COST FORM FOR HOG BUSINESS
(TEST ON LOT OF HOGS OF AVERAGE LIVE WEIGHT OF 250 LB.)

	Average Weight (Pounds)	Percentage Yield out of Live Weight	Current Market Price	Extension
Fresh hams	16–18	13½	21½	$ 2.90¼
Fresh bellies	14–16	12	20¼	2.43
Fresh shoulders	12–15	10	16	1.60
Fat backs	8–10	7	10½	.73½
Pork loins	8–10	10	23½	2.35
Spare ribs	.....	1	13	.13
Prime steam lard	.....	14½	11½	1.66¾
Trimmings	.....	2	10½	.21
Miscellaneous	.....	3	6	.18
Yield and gross value	.....	73	.....	$12.20½
Expenses (per cwt. alive)	.....	.....	.....	.51½
Hogs per cwt.	.....	.....	.....	$11.62
Hog cost	.....	.....	.....	11.25
Profit per cwt. alive	.....	.....	.....	$ .37

situation, and it may also be used by an accounting department in accumulating the actual figures on merchandising and operating transactions, thus becoming an integral part of the accounting records.

This form shows clearly that the hog business differs essentially from the cattle business in the fact that there is no one major product. No one product is as much as 15 per cent of the live weight of the hogs going into process. The yield column in this form shows the pounds of each kind of product derived per hundred pounds of live weight of hogs. Applying the current market value of each product to the yield percentage, and extending it, gives the value of each product per hundred pounds of live weight.

Thus, the hogs considered produced on the average 13½ lb. of fresh ham for each 100 lb. live weight. As these hams were worth on the current market 13 cents per pound the value of the hams per hundred pounds of live weight amounted to $1.76. The procedure is the same with each of the other joint products.

This method of cost figuring is the only method possible, with the information available, which is limited to: (1) the live-weight price and the cost of each lot of hogs purchased; (2) the yield of joint products—that is, the quantity and grade of each class of the resulting products; (3) the expense incurred in operations; (4) the current market value of such products.

With only this information at hand, the logical procedure is shown in the test form which emphasizes for the benefit of the merchandising executive these significant points: (1) the value of all of the products in the aggregate based on present market prices and reduced to the live weight basis. (2) The cost or the present market value of live hogs. (3) The cost of operations. (4) The margin of net profit or loss on the basis of current market prices.

This is information, which, when supplied promptly, is the most useful to the operator. It shows that it is inaccurate to divide the cost of the material between the various products resulting from the joint operations on the basis of the average cost of such raw materials per cwt. There is a wide range in the value of the product realized, from 14½ cents for pork loins and 13 cents for fresh hams, to 7 cents for fat backs and 4 cents for miscellaneous products, including certain edible products as well as bones, fertilizer, etc. To assume that every product costs the average amount per hundredweight would produce quite useless figures. This is an example also of the element of intangible shrinkage which occurs in so many of the joint-product operations. The yield of products in this test is 73 per cent of the weight of live hogs.

Careful division into departments is a distinct feature of the packing business, because of the many successive operations. The initial operating department is commonly known as the fresh

pork department, or killing and dressing department, and includes operations resulting in these products: fresh hams, shoulders, bellies, lard, etc., in their first stage, which are merchandisable commodities. Hence the operator has the option of selling these products in that state or transferring them to other departments for further processing. The hams and bellies, for instance, might be sold fresh or might be transferred to the freezer for storage (which occurs infrequently); or they might be transferred to the curing department. From the curing department hams may be sold fresh or transferred to a cooking department and manufactured into cooked hams, or might be transferred to the smoke house, where smoked hams are produced. Each of these departments represents separate commercial profit-and-loss departments, which have to meet the competition of independent concerns engaged in each one of these classes of business.

As these departments are customarily handled upon a commercial basis, the foundational department in which the joint operations occur must necessarily reflect the cost value and results shown in the test costs. Hence it is customary to draw together in this department the following figures:

1. As charges to the department: (*a*) The cost of the hogs purchased. (*b*) All expenses incurred.

2. As credits to the department: (*a*) The value realized from all products sold. (*b*) The full market value of all products transferred to other departments.

Clean-cut division into departments is necessary in order that the departmental accounting will provide the most accurate costs. It would be improper to include manufacturing and processing operations of the second and third stage in this department, for test costs must necessarily be based upon the value of the products in their first merchantable stage in order to emphasize the significant market relationships.

Material Costs and Joint-Product Values

As in major and by-product industries, an outstanding characteristic of most joint by-product industries is the narrow gross

spread between the material costs and the values of the joint products. Under both methods the results are substantially the same, but provision should be made for the selling and general overhead expenses in order to reflect correctly the market situation indicated by the cost figuring. The situation in joint-product industries differs, however, from that in industries producing major and by-products. For the latter the basic market relationship usually lies between the raw material market and the market for the major product, while in joint-product industries the significant relationship is between the market for the raw material and the aggregate of the markets for the several joint-product markets.

The market for each individual joint product reflects its own conditions of supply and demand, and its trend need not have any relation to the market trend of any of the other joint products. Illustrations of this situation are common. For example, in the petroleum industry there are individual markets for gasoline, kerosene, and many other joint products, each dependent upon its own conditions of supply and demand. In the hog business of the packing industry the markets for the various products, including pork loins, fresh hams, lard, etc., also have their peculiar individual conditions, and as has actually occurred, the trend in the price of pork loins might be contrary to the price trend of some other pork product. Similar situations exist in other joint-product industries. However, in all of these the basic market relationship is that lying between the aggregate value of all the joint products and the cost of the initial raw material.

CHAPTER XV

FUTURE BY-PRODUCT DEVELOPMENT

The variety of by-products manufactured directly by the packing industry, or serving as the basic raw materials of other subsidiary industries, has been pictured with some detail. It is a story of unusual progress with unforeseeable ramifications. Looking toward the future it seems almost useless to forecast specific developments, because the pathways of research have ever been unpredictable. Actual achievement has too often transcended or diverged entirely from the prophecy.

Nevertheless, the general lines along which by-product development in the meat-packing industry will continue seem rather obvious. Not only will new by-products be isolated and developed for human use, but the constant effort to process such by-products so that they may come in better grades, or find outlets of greater value, will continue increasingly. The future will undoubtedly see more inedible products prepared in edible form, and more low-value materials applied to hitherto undiscovered uses.

The next ten or twenty years will witness an extraordinary extension in the manufacture of by-products throughout all American industries. For example, there has recently developed widespread manufacture of by-products from American farms into commercial articles: lumber, wall board, paper, denatured alcohol, rubber, silk, and other products filling both old and new wants economically and satisfactorily. During the war the problem of substitutes for standard products brought preliminary solutions, and the possibilities opened up by such efforts have stimulated studies in all fields of agriculture and manufacture. The application of the *Ersatz* idea has made available to the public quantities of artificial silks and silk substitutes that were never before conceived. Rayon silk, made from cotton, has come into widespread commercial use almost overnight. It seems likely that

wall board and lumber substitutes made from cornstalks will prove of unexpected importance within the next few years.

The last decade has seen the packing industry in a period of flux, but it has nevertheless made greater progress than during any comparable period of the past. One of its characteristics has been the rapid changes in processing, especially in by-product manufacture. Without doubt it has kept in step with the older established industries in its rate of development, although the sensational stage has probably long since passed. It seems probable, therefore, that its principal improvements in the future will take the form of new processes for making old products and by-products, with a constant reduction in manufacturing costs and wastes. It will result secondarily, however, in a change in the character of these products and by-products, whereby they will be put to continually higher uses. For example, a new process of dry rendering developed since the war has made it possible, with reduction in expense and elimination of undesirable odors, to render fats and prepare meat residues in such a manner that the result is an animal feed, a product of much higher grade and greater value than its predecessor, fertilizer.

Dry rendering is but one instance of many improvements that are likely to occur among the greases and tallows. Research into progressive methods of treating these materials in order to get new products from them has been undertaken only recently, and the opportunity is great. It is perhaps in this field that the most significant changes in by-product operation will come. Preliminary to these developments will be more efficient methods of handling and processing the raw material. In general the problem in low-grade fat products is the improvement of color, stability, and flavor or odor. Thus far the economic pressure has not been sufficient to stimulate organized investigation in this direction; but there is little question of its urgency in the near future. There are many more oils and fats available for industrial uses than existed two or three decades ago. The increased production of vegetable fats and oils has been largely responsible for this situation, but at the same time there has developed an expansion in demand. While

separate uses formerly existed for animal fats and vegetable oils in nearly all fields, today processing has been so perfected that each competes quite definitely with the other, even in fields formerly distinct.

An example of one of the possibilities for animal fats indicates the probable trend for the future. Since the war the manufacturers in Holland of the so-called "Dutch lard" have been processing certain inedible animal greases, especially "white grease," so as to derive an edible product for European consumption. Thus far in America there has been no real need for developments of this type, since we have an adequate supply of fats available at prices which American consumers can afford to pay. If the rapidly widening consumption of fats and oils continues, therefore, it may be necessary to attack problems of this sort in the early future. Regardless of need, however, the severe competition between the producers of animal fats and vegetable oils is going to force developments of this sort, as one tries to provide satisfactory substitutes in fields already controlled by the other.

Another problem which must undoubtedly soon attain solution is that of making animal fats more stable. In the past the appeal has been to the housewife, and the stability sought has been that required under the average conditions for keeping fat in the kitchen. The rapid growth of the baking industry, however, and the creation of large-scale users of cooking fats and oils has engendered the problem of processing fats so as to retain their original chemical composition during long periods of storage in packages after baking. For the domestic user too, the housewife, there are certain important results which would follow from having animal fats, especially those used for deep frying, in a more stable form from the standpoint of the fluctuating storage conditions of temperature, moisture, etc., which they must now sustain, and from the standpoint of the amount of heat which may cause them to burn or volatilize.

Undoubtedly the most startling developments in by-products of the packing industry will be found among the pharmaceuticals.

Not only may new products as revolutionary as insulin be discovered, but a rapid expansion in methods of therapy, utilizing gland and tissue extracts, may be anticipated. The study of human metabolism is advancing prodigiously, and its regulation by endocrine and similar agents is becoming better known. Already attempts are being made to control two fundamental disturbances of the metabolism other than diabetes by technique corresponding to the insulin treatment, namely, such afflictions as Bright's disease, (albuminuria) and Addison's disease (derangement of the iron metabolism).

An entirely separate field in which the use of gland extracts is growing, and which offers great medical promise, is that of abnormal psychic conditions. Not only do the minor forms of depression, excitability, neurasthenia, etc., seem to yield to controlled glandular treatments, but even the major types of dementias and phobias are materially relieved.

One especial service which the packing industry can offer will come in the provision of quantities of these specialized tissue materials for research purposes. The identification of the various radio-active chemical elements was obtained only through the use of tons of ore in which they were hidden. The isolation and purification of thyroxin, the potent iodine-containing substance in the thyroid glands, was possible only when Kendall, in America, and Harrington, in England, applied the processes of separation to hundreds of pounds of animal tissue. The determination of the properties of chlorophyll required the use of enormous amounts of green leaves. The quest for the principle involved in curing rickets has already necessitated the saponification of several tons of cod liver oil, and yet a state of requisite purity, sufficient to establish the actual chemical nature of the potent factor in Vitamin D (anti-rachitic) has not yet been reached. Epinephrin from the adrenal medulla remained elusive until it was possible to secure it in adequate amounts. The chemistry of insulin will only be written when a wealth of material from the pancreatic glands is gathered together for the necessary separations and refinements. The

ultimate chemistry of animal and plant cells awaits the employment of operations on a factory scale, available only from the products of the packing industry. Not only will the industry contribute to the final preparation of these metabolic regulating substances, but under present conditions it is fundamental to much of the research establishing their necessity and functions.

The greater and more intensive research being given to all matters affecting human diet suggests a number of new by-product functions which may assist in furthering the use of the main product of the packing industry, meat. Recently interesting scientific results have been announced following the treatment of various foodstuffs with ultra-violet rays in order to prevent rickets. Whether such treatments can be conducted from a commercial standpoint remains for investigation, but if the results announced from the chemical laboratory are actually due to the ultra-violet treatment, there seems no question of their commercial applicability, especially for children's diet.

Extension of the preparation of edible meat by-products to a still further degree is certain. When the packer began canning meats which were perfectly edible but unattractive in their natural state, a line of investigation was started that has not received the attention in recent years which it deserves. The growth of sausage manufacture indicates something of the possibilities inherent in the process. More attractive and appetizing by-product uses will not only be discovered for sausage and canned meats, but further ranges of products will undoubtedly be developed in the form of delicatessen and luncheon meats. The availability of such meats, the small amount of waste, and the relatively low price of many such products, will stimulate a wide usage among consumers hitherto limited in their supply of meat products.

The foregoing survey of by-product possibilities in the meat-packing industry makes it apparent that only a beginning has been made in a more scientific utilization of all by-products for commercial purposes. That the future will see this extension into a variety of fields impossible of anticipation at present seems

unquestioned. One never knows when new demands, of which we are not conscious today, will stimulate new products. By developing commodities of continually higher grade and adapted to more refined and wider uses, the livestock and packing industries will be utilizing more efficiently than ever their vast store of raw materials which constitute a fundamental source for the ministration of an almost infinite variety of vital human wants.

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